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TRANSACTIONS

AND

PROCEEDINGS

OF THE

Royal Society of Victoria.

VOL. XVI.

Edited under the Authority of the Council of the Society.

ISSUED 30th APRIL, 1880.

THE AUTHORS OF THE SEVERAL PAPERS ARE SOLELY RESPONSIBLE FOR THE SOUNDNESS OF THE OPINIONS GIVEN AND FOR THE ACCURACY OF THE STATEMENTS MADE THEREIN.

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Ю. Любовь Сергеевна

Royal Society of Victoria.

1879.

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PRESIDENT'S ADDRESS.

Royal Society of Victoria.

ANNIVERSARY ADDRESS

OF

The President,

Mr. R. L. J. Ellery, F.R.S., F.R.A.S., Government Astronomer.

(Delivered to the Members of the Royal Society of Victoria, at their Annual Conversazione, held September 1st, 1879.)

Gentlemen of the Royal Society,

We meet to-night to commemorate the entrance of our Society into its twenty-second session, and once again there devolves upon me the pleasant task of addressing you upon the past year's history and present affairs of the Society, as well as upon the more interesting points in connection with the progress of science in the world generally since last we met together on a similar occasion to the present.

The ordinary meetings of the Society have all been fully occupied with scientific papers, accounts of original experiments or discoveries, exhibits of new or improved scientific instruments, and the discussions emanating from them. Our transactions will show how far your Society has fulfilled its mission and trust during the past twelve months, and although we cannot congratulate ourselves on any unusual vigour or progress, I think we may justly look back with satisfaction on the past year's work.

The plan of printing and distributing original contributions immediately after they have been read or received at the ordinary meetings has been found a good one, and I believe has imparted fresh vigour to our proceedings.

The section for mathematics, astronomy, physical science, and engineering, called section A, has been again formed, with a strong list of members, and two or three meetings have already been held. These section meetings are somewhat less formal than our ordinary ones, and members are therefore encouraged to bring forward many matters of value and interest which are either not ripe for or not considered of sufficient importance for a communication to the members' meetings. It is not of course intended that the section meetings shall in any way absorb matters which should come before the full Society, but rather to discuss and elaborate incomplete experiments, investigations, inventions, &c., prior to submitting them at the ordinary meetings. I am glad to hear that several of our members, students of natural history, are also about to form sections C and D.

I stated in my last address that the Council had appointed a committee to consider the best means of broadening the basis of our Society, and opening our ranks to young men whose taste and education would lead them towards us, but to whom the monetary obligations of ordinary membership were a serious consideration. The Committee reported in favour of the formation of a new class of members, to be styled "associates," who should be nominated and balloted for as in the case of ordinary members, but who should be admitted without entrance fee, and with half the annual subscription demanded from members, and that, with the exception of the power of voting or taking part in the government of the Society, they should enjoy the same privileges as members. This report was approved of at a special general meeting, and a rule added to our code accordingly. I am glad to say this reform has already resulted in the enrolment of a considerable number of young men earnestly interested in the objects of the Society, and who have already given evidence that the almost boundless fields for research and investigation which are daily widening out before us will not be left entirely unexplored by them.

Our relations with foreign societies of a kindred nature are extending every year, and the library has been so much increased by exchanges and donations, that more shelf-room is urgently required.

This brings me to the subject of the proposed alterations in the internal arrangements of the building, to which I made reference in my last address. The proposal then made —to continue the floor of the library across this room, on the level of the cornice, which would give us a lecture-room on the same floor as the library, and two good rooms on this floor underneath it—is now generally approved of by the Council, and Mr. Reed has been requested to ascertain the cost of carrying this plan out. If such an alteration should be made, it is probable that one of the lower rooms would be devoted exclusively to the library. It is now absolutely necessary that the exterior of the building should be put into a somewhat more sightly habiliment, and the Council is taking steps with the view of getting this done, as well as the interior alterations.

The financial position of the Society continues satisfactory, and with the aid of the annual subsidy of £200 for printing our transactions, so liberally granted by Parliament, we have been able to keep up prompt publication of the Society's proceedings, while the ordinary revenue has been carefully nursed for the repair and alterations of the building, the urgent necessity for which has been continually pressing on your Council. It is hoped that these repairs may be accomplished without incurring debt, but the time has arrived when they can be no longer delayed, whether it should become necessary to borrow money to carry them out or not.

I must not detain you longer with the domestic affairs of the Society, but will invite your attention to a few matters of general interest and importance which characterise the past year's advance in knowledge.

In a retrospect of the progress made in astronomical and physical science since our last gathering I may be excused for giving the doings of our Observatory my first attention;

and when I tell you it has continued its usual work in astronomy, meteorology, terrestrial magnetism, and other matters kindred to these, you will be assured that neither observers nor instruments have had time to rust.

I have on previous occasions referred to the supposed existence of a planet or planets between Mercury and the sun; and last session I gave a brief account of the reported actual discovery during the eclipse of July 29th, 1878, of such a body by Professor Watson, a well-known and skilled American astronomer. At the time, and indeed since, considerable doubt has been expressed by astronomers generally as to whether the body seen during the darkness of totality was really a planet, or, indeed, anything but one of the known stars of the constellation Cancer; and in one of the "Notes from the Observatory" I alluded to the disbelief in this discovery expressed by another well-known American astronomer. Professor Watson replies to the criticisms on his observations in the columns of the *Astronomische Nachrichten,* and states most emphatically that the two stars he observed during totality were new, and not any of the known stars of Cancer; and he, moreover, shows that the conclusions arrived at by his critics as to his mode of observation are altogether erroneous. He says:—"Whether or not the two new objects which I observed were intra-Mercurial planets, I cannot positively assert, but I certainly have the right to express my honest belief that they are." This letter will probably remove many doubts, and for my part I cannot conceive how so old and skilled an observer as Professor Watson could have made the blunders attributed to him by his critics. The probability of the existence of intra-Mercurial planets is certainly strengthened by these observations.

Assuming that one of the bodies seen by Professor Watson was really a planet, Dr. Oppolzer, of Vienna, considered it probable that it might cross the sun's disc in February last, and he consequently sent a telegram to southern astronomers, requesting a watch to be kept on the sun's disc on a

certain day. This was faithfully done at our Observatory, but without success.

An unusually close conjunction of the planets Saturn and Mars took place on the morning of the 1st July last, and the weather being fine and sky perfectly clear, very satisfactory observations of the occurrence were obtained. A capital opportunity of testing the accuracy of the planetary tables, as regards the two bodies concerned, was afforded by so near an approach, and at the same time the presence of both planets in one telescopic field enabled observers to compare the physical appearances and especially the colours of the two planets with ease and certainty. The contrast of colour observed was remarkable, and certainly greater than would be expected by one who had been accustomed to observe them separately; Saturn appeared of a greenish yellow colour, while the orange tinge of Mars was ruddier than usual. In the course of the evening, I hope to be able to show you by a projection on the screen a fair representation of the telescopic picture presented to an observer on this occasion.

The large number of drawings, and the great amount of information relative to the southern nebulæ now collected from observations with the great Melbourne telescope, are still unpublished; but I am glad to say that, after numerous fruitless trials and disappointments, a portion of the drawings have at last been successfully printed by the lithographic artists of the Mining Department, and these will shortly be published with descriptive letterpress.

The great telescope itself continues to perform satisfactorily whenever the atmospheric conditions are good, and it is kept steadily engaged in its special fields of research. It is probable, however, that during a portion of the coming summer it will be devoted to photographic work, principally in connection with the moon.

The progress of astronomical science generally during the period under review is not marked by anything of unusual interest.

Astronomers are already beginning to prepare for the

next transit of Venus, which occurs in December, 1882, but the doubtful success which attended upon many of the arrangements made for the transit of 1874 renders it probable that much more limited preparations will be made for the coming one. The photographic results, from which so much was hoped, turned out a disappointment throughout, and it is doubtful if this method of observation will be adopted again. It has also been found that the value of the observations obtained at many places were largely decreased from uncertainty as to their precise longitudes. The Astronomer-Royal of England, in his last report to the Board of Visitors, says—"We are naturally looking to the transit of 1882, and the general impression appears to be that it will be best to confine our observations to simple telescopic observations or micrometer observations at ingress and egress, if possible, at places where longitudes are known."

All matters concerning the physical condition of the moon are usually of popular as well as of scientific interest, and any information which will throw light on the question whether our satellite is absolutely dead, or whether signs of residual activity can still be observed, is always received with attention and interest. It is not unusual to hear of supposed changes still going on in the moon, of the "activity of a crater," of a lunar land-slip, and so on; but, as a rule, such reports are generally found to originate in the protean aspects the lunar craters and other features present under changing illumination. An instance, however, has occurred lately, and to which I have already referred in public print, that appears to be a veritable case of change; and several experienced observers bear testimony to the appearance of a new crater-like spot in the vicinity of the small but well-known crater Hyginus, near the centre of the moon's surface, as seen by us, where no such crater or spot was noted before. I saw the object on the sunrise terminator, when it could be most favourably observed, on the evening of the 24th instant, and it appeared as an

undefined and somewhat nebulous spot, and conveyed to me the idea of something in process of formation or change. At the last meeting of the Royal Astronomical Society, Mr. Neison, one of our best selenographers, described and gave drawings of what he saw in March and April; and another well-known observer, Mr. Green, also furnished drawings, which agreed with Mr. Neison's. The well-known Melbourne photograph, taken with our great reflector, was again used as a referee, so we must suppose it is still the best photograph of the moon extant. The position of this new spot with regard to Hyginus will be shown in the course of the evening; and Mr. Neison says about it—speaking of the drawings made by Mr. Green and himself—"The two drawings agree perfectly. There is no doubt, therefore, that there now exists in this region a large conspicuous object where no such object existed before; for it is so large that it could not have existed and have been overlooked by previous observers when they drew the much less conspicuous objects on all sides of it."

I told you last year of Professor Draper's discovery of the existence of oxygen in the sun. He has continued his researches, and has, I think, established the fact beyond all doubt by most exhaustive experiments and observations. Another element must now, therefore, be added to the list already revealed to us by the spectroscope. This gas has not yet been found to exist in our luminary in the two stages of temperature in which hydrogen can be observed, showing bright lines in the chromosphere, and dark in the photosphere, for Professor Draper has found it only in the bright line stage, indicating a temperature of far higher intensity than that in which the vapours of the most of the other substances in the sun appear to exist.

The sun has been passing through the period of minimum sun spots, a period which appears to recur every 10 or 11 years. Out of 169 photographs obtained with the heliograph, at our Observatory, 20 show the presence of sun spots, but represent only 7 occasions on which a different

group of spots occurred. At Greenwich, out of 150 photographs, 29 show sun spots. As is usual during these periods, magnetic storms and auroras have been much less frequent. Within this period, also, we have had dreadful famines in India and China, serious droughts in Australia and other parts of the world; and, to crown all, a cloud of commercial depression and disasters appears to have fallen on the earth, darkest where commerce usually flourishes most. An occasion has thus been afforded for reopening the question of a connection between the solar and terrestrial conditions, and there has been a considerable amount of discussion and controversy upon the subject. Investigations of the rainfall statistics in India and elsewhere, where records over a long series of years are available, have been diligently made to compare with the now well-known sun-spot period, and while weighty evidence has been adduced from some regions in favour of one side of the question, the other regions furnished it in favour of the other side. It is generally conceded, however, that the earth's magnetic condition is much more disturbed, and that auroras, cyclones, and storms in some regions are also more prevalent during the period of sun-spot frequency than during the minimum period. It is also suspected, and almost admitted, that the influence exerted by the sun on these terrestrial conditions is intensified by certain planetary positions, while the late disastrous seasons in many parts of the world present one instance at least of a coincidence between a minimum sun-spot period and droughts and commercial crises. Observant financiers and commercial men have often remarked that a "wave" can be traced in the "money market," whose period is from 10 to 11 years, and this has given colour to the proposition of the coincidence of no sun-spots with commercial declines, against which Mr. Proctor declaims so vigorously. Few who know anything of physical science will venture to deny the possibility of the connection; there are many, however, and I rank myself among the number, who maintain that sun-spots and prosperity, although they may sometimes

come in company, are certainly not yet proven to be in the relation of cause and effect. A few more periodic coincidences will be required to show a satisfactory appearance of "a law" in the matter; but as the case now stands, science can only state that experience has taught us that bad times, with droughts, floods, or other physical disasters, inevitably follow, though perhaps not at regular intervals, periods of prosperity and good times as surely as one ocean wave follows another, and that the great lesson to be learned is to lay up for the metaphorical rainy day, and provide in times of prosperity and plenty for the trough of the wave which naturally succeeds.

While new discoveries in electricity appear to have come to an end for a time, the past year has been most remarkable for the numerous and wonderful applications of former discoveries to practical purposes. It has been a period of enormous inventive activity in this direction, and something approaching to a craze has seized upon the civilised world with regard to the applications of this force. This applies more particularly to the electric light, concerning which so much has been written and said of late that I shall content myself with the remark that the public have been led by sanguine inventors and gushing writers to a too exalted idea of the practical value of this light, and as they become familiar with its advantages and drawbacks become proportionably disappointed. For many special purposes this beautiful light can have no rival but daylight; but to suppose it can yet awhile replace our ordinary modes of illumination, or, indeed, that it can ever do so economically, amounts to a craze, or something very like one.

The telephone and microphone are now, in their improved forms, really scientific instruments, and most useful tools in many investigations. The capabilities of these instruments were at first very much over-stated, and the improved ones scarcely attain to the excellence claimed for the early crude forms. It appears now possible to construct a telephone by which words spoken from a distance can be heard and under-

stood by a number of persons at once, indeed, to be intelligible all over a large chamber. Edison's speaking telephone appears, from what has been written of it, to accomplish this most satisfactorily. A combination of the microphone and telephone forms a most delicate instrument for the determination of the tremors and vibrations of the earth which occur in the neighbourhood of active volcanoes, and by its aid Professor Palmieri has been able to detect tremors and sounds otherwise insensible, which were found to precede and accompany different phases of the recent eruption of Vesuvius, and which afford certain warning of various stages of volcanic action. A current from a galvanic battery traverses a circuit in which is included the telephone and the delicately balanced carbon contact pieces of Hughes's microphone. The microphone is placed at the observatory, nearest the active portion of the crater, and the slightest tremor vibrates the two pieces of carbon in balanced contact, and produces peculiar sounds in the telephone (at a safe distance from the crater), which Professor Palmieri is able to interpret. Another interesting application of these combined instruments is Professor Hughes's indication balance, which Mr. Joseph has already brought under notice of this Society; and as he will exhibit it to-night, he will, I am sure, explain its principles of action to any one interested in the matter.

In my last address I called your attention to the labours of our fellow-member and renowned botanist, Baron von Müeller, and referred to the various botanical and allied works which he had already published or which were in progress. During the past year he has obtained additional knowledge of the Australian flora by personal examination of the Lachlan River district, as well as from an extensive series of plants obtained by Mr. John Forrest during his triangulation of the Nichol Bay district, and numerous contributions from amateur collectors. The results are given in the eleventh volume of the *Fragmenta.* A report on the *Forest Resources of Western Australia,* from the pen of the

Baron, has lately been published in England at the expense of the Western Australian Government; this gives the results of his personal observations in the summer of 1877 of the country lying between King George's Sound and Shark's Bay. The fourth decade of his valuable work on the eucalyptus family of Australia, which I referred to last year, will be completed during the next three months or so. The practical utility of such a work cannot well be overrated, for a knowledge of the peculiarities and properties of the various orders of the immense family of gumtrees is a matter of considerable importance and value, not only to the botanist and arboriculturist, but also to the engineer and the artisan. It is to be regretted that the author does not now possess the requisite means for prosecuting his researches, commenced long since, upon the properties and products of living plants, and especially on this extensive genus. His work on *Select Industrial Plants* is, I hear, being republished as an Indian edition in Calcutta, by permission of the Victorian Government, with additional important matter relating to the introduction of extra-Indian plants for forest culture and for purposes of food.

Our members interested in natural history have no doubt been pleased to see that the botanical value, from an educational point of view, of our beautiful gardens on the Yarra has not been lost sight of by the energetic curator, Mr. Guilfoyle, in his desire to make them a place of pleasure and recreation for the public generally. The classification he has adopted in the decoration of some parts of the gardens is useful to many a student and lover of botany, and no doubt will tend to an encouragement of the study of that science.

The achievements and acquisitions of the exact sciences, as a rule, I believe, appeal more readily to the interest and attention of the many than do the discoveries, improvements, and applications in the less exact ones. Yet if we take the sciences of medicine, sanitation, biology, and so on, one would imagine that as they are so much more closely

connected with our health, well being, and our very lives than are the mathematical and many of the physical sciences, they should be subjects of paramount public interest. That such is not the case, however, is pretty well known. Nevertheless, earnest men plod away with investigations in these fields of research, and gradually but surely accumulate knowledge, which is of far more benefit to mankind generally than to those who work for and obtain it. I do not mean to say that those who so benefit mankind do it from pure philanthropy, for few work in science with that alone as the goal. The pleasure and expectation which accompanies the actual process of investigation is with many ample compensation for time and labour given, and others gain a direct reward in the acquisition of extended knowledge during their research, but where the result is some elucidation or discovery which not only intellectually enables the worker, but confers a substantial benefit on his fellow-creatures, it is a "game" indeed "worthy of the candle," whether the prime mover to the investigation was κυδος or philanthropy. We have already amongst us many who devote time and brains to scientific research in medicine and sanitation, and it would occupy me too long to recount how large an increment in the power to prevent and alleviate disease and suffering has been earned in our small colony.

The past year's history of medical science here is prominently marked by two circumstances—namely, a most important discussion and a new literature concerning the origin and propagation of the fatal fever known as typhoid, and a controversy as to the prevalence of phthisis in Australia generally, and especially in this colony. In some of the recent numbers of the *Lancet* two reviews appear of a work by Mr. William Thomson on "Typhoid Fever," which I referred to in my last address, and which has been re-issued with additions. The reviewer stamps the book as a most valuable contribution to the knowledge of the cause and manner of propagation of this disease, but he does not agree with all the writer's views. Mr. Thomson vigorously

supports the "contagion" theory of typhoid, in favour of which he adduces powerful evidence, and contends that this fever can never arise *de novo* without the initial germ or specific poison. The undeniable increase of this fatal disease amongst us every autumn should make us gratefully hail every honest attempt at the elucidation of the mystery which surrounds its true cause and the manner in which it is conveyed from place to place, and whether or not Mr. Thomson's views are ultimately found to be the true ones, the public are at least indebted to him for his evidence and opinion, which, at all events, awaken us to a better knowledge of this autumnal scourge.

A very decided difference of opinion exists among medical men concerning the fitness of our climate for consumptive people, and the prevalence of that disease amongst us, especially among the native-born. Statistics have necessarily afforded the grounds upon which both opinions have been based, and as it has been well said, "Statistics will prove anything," both parties have established their cases satisfactorily to themselves, though perhaps not to those most concerned. Mr. Thomson here again takes one side, and Dr. Singleton, Dr. Bird, and, I believe, Dr. Williams, the other—all authorities whose opinions are of weight. Mr. Thomson contends that phthisis is as prevalent in Melbourne and the suburban districts as in England, while the others take the reverse side. If it is so common among us as to be a question of opinion, or of the method of treating statistics, whether it is worse here or in the mother-country, the commonly received opinion that our climate offers comparative immunity from such disease is no longer tenable. It is somewhat remarkable that an alarming fatality among the young aboriginals at the various protection stations has occurred of late, and from what is stated I think there can be little doubt that the cause is phthisis. If this be so, and the aboriginals were formerly free from it, it will be evidence in favour of its being in a sense "contagious," a view that is now rapidly gaining ground among leading medical

men, and one upon which Mr. Thomson in his work on the prevalence of *Phthisis in Victoria* lays considerable stress, and in a community where this disease has headed the mortality list for the last twenty years, this question becomes one of far more gravity and importance than that of comparative statistics.

The present position of what is styled the germ theory has not advanced to any great extent during the year. The presence of germs and vegetable growths of fungoid or algoid forms has been found to be much more common in the blood and other fluids, as well as in the tissues and mucous surfaces of the human body, than was formerly supposed, and it has lately been shown by Mr. Butlin, M.R.C.S., in a contribution to the Royal Society of London, in March last, that so-called "germs," especially *Bacillus* and *Micrococcus*, are nearly always present in the "fur" on the tongue, "which," he states, "there can be little doubt consists chiefly of these two fungi."

Our two great museums—the one at the University, and the other in connection with the Public Library—are getting more and more complete each year. Since I last referred to these institutions Professor M'Coy has added numerous valuable specimens to most of the departments in the natural history museum, and the collection has now become most valuable for reference by students, as well as instructive and interesting to the ordinary public, which, from the returns published, appears to thoroughly appreciate Professor M'Coy's labours in this direction. There are now nearly 45,000 specimens labelled and classified in the cases. Six decades of paleontology, and three of zoology, have already been published, and are highly spoken of by scientific men in Europe. Professor M'Coy tells me he has an additional volume of each branch now in the press. The technological museum at the Public Library has been most carefully arranged, and the classification into definite departments of over 30,000 specimens, illustrating applied science and technology, including natural products, their application

and use in manufacture, has increased the value of the collection in an educational point of view immensely. The school of technology continues in full operation, and the members of this Society have frequent opportunities of judging, from the papers contributed by its director and our fellow-member, Mr. Newbery, what good work is done in the laboratories there in mineralogy, metallurgy, and technical chemistry. The classes have been well attended, for on inquiry I find that the number of pupils in elementary chemistry was 250; in practical chemistry, 30; engineering, 23; telegraphy, 64; and modelling, 6.

In conclusion, I would return for a moment to a matter of moment to this Society. Some little time since an article appeared in one of the weekly papers, entitled, "Science in Australia," in which the scientific men of Melbourne are accused of apathy, and this Society, not only of doing little scientific work, but not publishing what it does do till years after. The writer, perhaps, like Rip Van Winkle, has been asleep, and imagines things have stood still for a decade or so, or he would know that for nearly three years our transactions have been published every month, or at least at very short intervals; or, more likely, perhaps, occupied himself in some scientific byway, he cannot recognise the work done in wider fields. However, it may be as well to ask ourselves if such criticisms fairly apply to those supposed to represent science in Melbourne. Is that work by which the great forces of nature, the mechanism, laws, and order of creation are gradually opened as a book to the world, revealing to mankind the endless resources at his disposal, so neglected in this prosperous community as to give grounds for such a censure? There are very few in these colonies who choose so-called science as an occupation or amusement that are sufficiently endowed with the world's goods to permit a devotion of much time to original research; there are, nevertheless, a great number who, after their daily bread-winning labour is over, devote themselves to scientific study, and it is surprising how much valuable addition to our knowledge

in the directions indicated comes out of work done for recreation; and while it must be admitted there are many among us from whom scientific work might naturally be expected who have either left the ranks or lag behind, the proportion of people here who occupy themselves and spend their spare time in various kinds of scientific observation and research is much greater than in any place I know of in the mother-country, or, I believe, in Europe. Although there are no Newtons, Faradays, Owens, or the like among the pioneers of scientific work in these colonies, there are among our younger students numbers of possible ones, carefully and modestly following the difficult trails of these great men; and however remote may be the hope that any will ever attain to the eminence of such men, it still remains attainable. Let it be also remembered that no occupation, not even that all-absorbing one of "making haste to be rich," which dwells among us here like a burning perennial fever, can confer such real and lasting pleasure as is experienced by earnest and devout students of nature and God's laws which govern it.

TRANSACTIONS.

Art. I.—*On the Relation between Forest Lands and Climate in Victoria.*

By R. L. J. Ellery, F.R.S.

[Read 8th May, 1879.]

The late recurrence of dry seasons in the southern portions of Australia has once more attracted grave public attention to questions concerning the rainfall and conservation of water, and, as is usual during such climatic vicissitudes, numerous opinions and speculations as to periodicity, causation, and so on, find place in the columns of the press. The one, however, which has perhaps obtained more than ordinary interest is that which has reference to the influence of our forests upon rain precipitation and climate.

The full significance of this question only presses on the *public* mind in times of drought and water famine, but it has occupied the attention of scientific men in most countries as a great climatic problem for a long time past. In some instances a partial solution has been reached, apprising the people that such and such deplorable changes of climate were the inevitable and natural result of artificial changes of the earth's surface, to which it had been subjected for centuries. In some countries, therefore, we see what was originally a mild and fertile climate replaced by one of comparative sterility and violent meteorological extremes.

In Australia generally, but more especially in its southern portions, the rainfall is the all-important climatic element; and it is not too much to say that, with an adequate rainfall seasonably distributed throughout the year, the climate of southern Australia would vie in fertility with that of any part of the globe.

There is a law apparent in the general distribution of rainfall upon the earth's surface dependent upon the latitude, which may be roughly stated thus:—While the

average annual rainfall over equatorial regions is about 104 inches, this amount is decreased to

85	inches in	latitude	10°
70	,,	,,	20°
40	,,	,,	30°
30	,,	,,	40°
25	,,	,,	50°
20	,,	,,	60°

Our rainfall is approximately in accordance with this law, and although local causes may determine a greater or less amount, the coast-line yearly average may be taken as 33 inches. It would appear, therefore, that our annual average of about 30 inches is what we might naturally expect. Locality, however, has such an important influence in the distribution that in some places not widely separated the annual amount of rainfall will vary as much as 9 inches. The question, therefore, presented to us is this:—Does the presence or absence of forest land govern this unequal distribution? Will clearing away timber affect the rainfall by diminishing or increasing it in any particular locality, or in any other way? and (what is also of the greatest importance) do forest lands aid or prevent the natural conservation of the rain which falls to our share? On these points climatic statistics are meagre, and from only a few countries can we derive any definite experience. This colony has not been settled for a sufficiently long period to afford unmistakable evidence; and in discussing the question, we must in a large measure necessarily fall back upon the principles and canons of physical science.

Experience, however, supplies us with one or two important facts, first amongst which is that *no marked diminution of average annual rainfall* over any extensive region can be traced solely to denuding the earth's surface of forests, although the local effects of such a proceeding are usually well marked.

If we take countries in temperate latitudes where absence of forest is the normal condition of the surface, we find, with some exceptions, the average annual rainfall agrees fairly with the distribution according to latitude, as given above; but this average is made up by excessive falls at one portion of the year, or at isolated times, with excessive dryness and scarcity of water as the usual state of things. In some of the timberless districts at the Cape of Good Hope, the beds of the streams, which are dry or nearly so three-fourths of the

year, show how they are torn from time to time by excessive rain precipitation. This is also the case in some parts of temperate South America, Persia, India, Thibet, and Tartary—and, indeed, it is not unknown to us in Australia. In such places drought is the normal state of affairs, though the annual rainfall is probably greater than in wet England. The simple amount of rainfall does not, therefore, appear to be the only factor which determines a country's humidity or dryness; while we gather from the instances referred to that the presence of forests must be taken as one of no small importance.

From carefully conducted experiments it is found that the temperature of trees in forests has a very different march from that of the air, for while the maximum temperature of the air is usually reached about three p.m., that of a forest tree occurs about nine p.m., and while the air is subject to rapid changes, trees are exceedingly slow to alter. The obvious result of this is that the days in a forest are cooler and the nights warmer than in open country. Summer temperature is diminished, and that of winter increased. It is also a well-known fact that forests diminish evaporation from the ground, and act as conservators of moisture.

The greatest extremes of night and day temperature occur in open country, where the unshaded soil readily absorbs the radiant heat of the sun and becomes many degrees hotter than the air. Again rapidly radiating back the heat into space at night (unless it be cloudy), the surface cools down to a temperature far below that of the air, often below freezing point in the middle of summer. Vegetation has a hard struggle for existence; none but the hardiest species survive, and excessive dryness of the untimbered country (where such country prevails to any extent) undoubtedly engenders meteorological conditions unfavourable to rain precipitation. It has also been found that the temperature of the sides and slopes of mountains is modified even in a more marked degree than that of level country by the presence of forests.

So much, then, can be gathered from actual observation and experience in other countries. I now come to our own experience. The greatest annual averages of rain in this colony occur either on or in the vicinity of mountain ranges, and especially on their southern or seaward slopes, and the

least ones on open untimbered level country. For instance, our greatest observed rainfall occurs at Fern-tree Gully, on the south-west slope of the Dandenong Range; next to this come Berwick, and Lower Macedon; then Daylesford, Trentham, Hastings, and Birregurra, all closely-timbered localities or near forest-clad ranges. Our lowest rainfall takes place about Swan Hill and along the western Murray; then comes the Horsham district, and that remarkable area of small rainfall surrounding Cressy, Darlington, Wickliffe, &c.

From this it would appear that, in Victoria, at least, forest lands, if high, are favourable to rain precipitation; while level, open, and sparsely-timbered country is undoubtedly less fortunate in this matter.

We now come to another part of the question—Will denuding the forest lands of timber increase or lessen the rainfall, or will it affect the climate, and how?

Our experience in Victoria does not reach far enough back to answer this question decisively. We have rainfall statistics of only a very few places prior to 1862, and from stations generally distributed over the colony only during the last ten or twelve years. These data are not sufficient to show whether or not any marked change has occurred.

In a few localities, where the clearing of mountain ranges has been carried on extensively, it is gathered from local information that the perennial mountain streams have much diminished; but no actual diminution of rainfall has been shown to have occurred. Yet, nevertheless, it may reasonably be inferred that such has been the case. While, therefore, we fail to obtain any satisfactory reply to this question from precise observation or measurement, physical science will furnish a trustworthy answer to a large part of it.

It has already been remarked that forests greatly reduce the extremes of temperature to which the ground would otherwise be subjected, keeping it warmer by night and cooler by day. *Evaporation from the surface* is also greatly retarded, so that in forest lands the benefits of rain precipitation are thus unusually enhanced, and not only for the timber-clad districts themselves, but also for all areas supplied by streams of which these form the gathering grounds.

Evaporation is always going on from the leaves of trees, and this tends considerably to cool and render less dry the

air over forests. Air nearly saturated with moisture, drifting over the heated surface of the open country and meeting with this cooler stratum, not unfrequently becomes converted into a falling mist or actual rain. In fact, the diminution of temperature over the forest has the same effect upon moisture-laden winds as a range of hills—namely, to encourage precipitation.

It is highly probable that forests have another influence on the atmosphere, which, although not yet thoroughly recognised, and perhaps not generally admitted, may nevertheless prove to be most powerful. I refer to electric influence; and from the results of a few observations and experiments I have made at different times on atmospheric electricity in forests, and some interesting phenomena I have witnessed, I feel certain that what may be called *electric exchange*, or the balancing of the electric tension of the lower strata of the atmosphere over forests, plays an important part in condensation and precipitation. In making an electric contour over large trees in forests, I have always found the equipotential line to come closer to the tops of trees than any other objects; and this may possibly account in part for the well-known rapid condensation by tall trees of the drifting mist in hill forests, by which an immense amount of water, not counted in our rainfall, is annually precipitated.

Some months ago when on Mount Macedon, about 3000 feet above the sea, in company with our Vice-President, Mr. Foord, we watched the gradual condensation of air-borne moisture into mist-clouds. As it was driven up the southern slopes of the mountain, our attention was attracted by some peculiar rifts in the mist-clouds, which occurred as they passed over an isolated dead tree near the summit of the mountain. They appeared as almost vertical dark streamers radiating from the topmost dead limbs of the tree, and waved about much in the same way as one sees the brush discharge from an electric machine, or the secondary discharge of an induction coil. We were both impressed with the idea that the phenomenon was electrical. The part electric tension plays over the surface of forests, presents, I think, a new field for meteorological enquiry.

From these facts, meagre as they are, I think it will be conceded that our forests play a most important part in our climate; that without them, while our rainfall might

not diminish, it would become more fitful, and the country more and more exposed to extremes of temperature, our winds drier, and our soil more arid and sterile. For conserving our allotted rainfall, tempering and moistening the burning equatorial winds, for moderating the sun's powerful rays, and the rapid terrestrial radiation, which produces such low temperatures at night, and for checking rapid evaporation, our forest lands are the chief agents. Denude our timbered ranges, clear away our lower forests, and our climate will soon become like those of some of the similar latitudes in the northern hemisphere already referred to, where no middle state is known between a scorching arid summer and an intensely cold and equally arid winter, tempered only by occasional heavy rains of short duration.

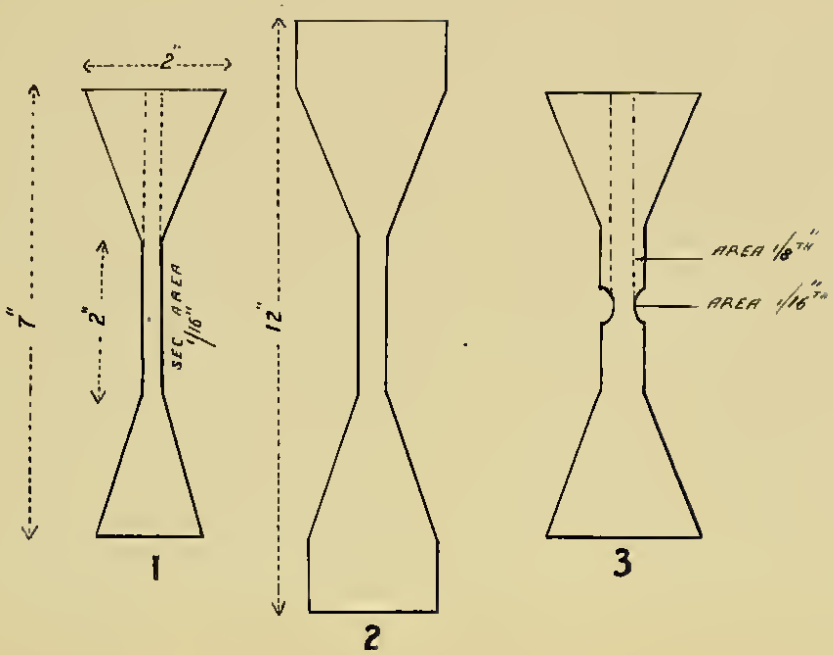
Moderate forest clearing in very humid climates is doubtless beneficial, and many tropical regions have been rendered habitable and healthy by the process; but in a dry climate like that of Southern Australia, the indiscriminate clearing of timbered lands invites an ever-increasing aridity of climate and diminishing fertility of the soil.

Art. II.—*Experiments on the Tensile Strength of a few of the Colonial Timbers.*

By Fred. A. Campbell, C.E.

[Communicated May 8th, 1879.]

These experiments were made at Geelong during a short period of leisure time. As the power I could bring to bear upon the specimens did not exceed a ton, I found it necessary to work upon specimens with a sectional area of one-sixteenth of an inch. The form of specimen first adopted was that shown in figure 1, but as with the stronger woods the specimens gave way by the detrusion of a piece from the centre, as shown by dotted lines, I adopted a form, as in figure 2, five inches longer. The apparatus used was of the


2"
7"
2"
SEC. AREA 1/16"
12"
AREA 1/8TH"
AREA 1/16TH"
1
2
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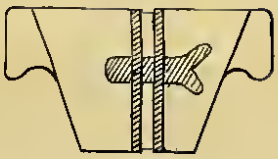
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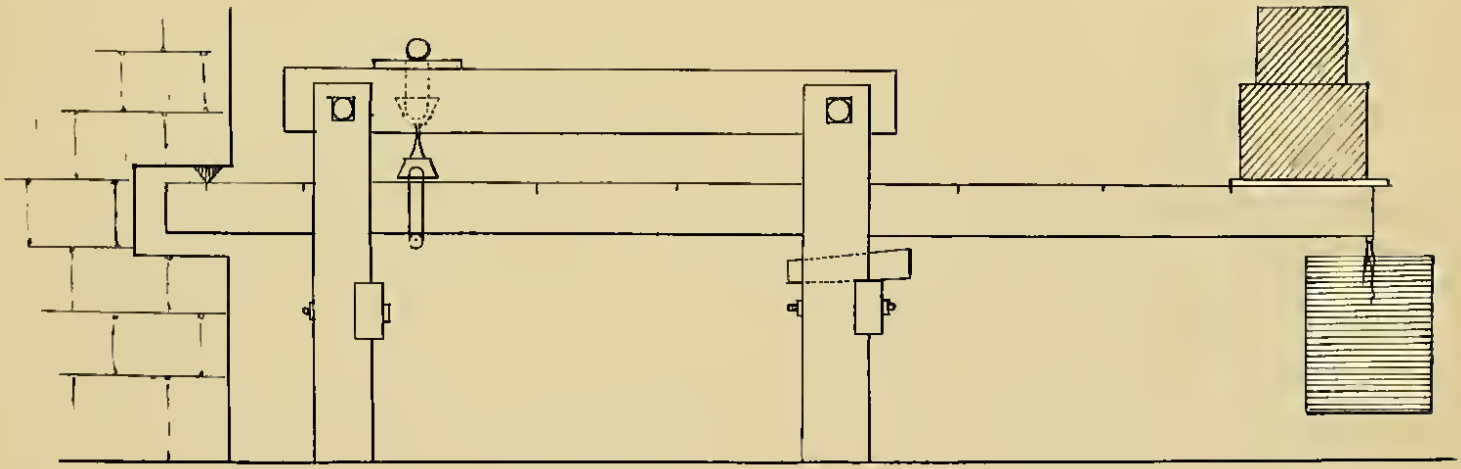
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roughest description, but it answered its purpose. The specimens were held at each end by wrought-iron clips, as shown in figure 4, and then hung and pulled by means of a lever, as shown in figure 5. Using known weights and sliding them along the lever, which was graduated, I readily obtained the breaking weight of the specimen. The weights were always applied in such a way as to cause a gradually increasing stress upon the specimen, perhaps fifteen to twenty minutes being taken to work up to the breaking weight.

The wood was well seasoned, and probably better on the whole than the average used for engineering and building purposes.

With the exception of the blackwood and deal, all the specimens of the same kind of wood were taken from one piece.

With these facts, and the numerical result of each experiment, the true value may be placed by anyone upon what has been done.

Of course, the numerical value of the tensile strength of any timber is a quantity which varies greatly, being affected by age, seasoning, defects, part of tree from which the specimen is cut, &c., and the limits within which it varies can only be fixed after numerous experiments made under different circumstances.

Now, the experiments noted hereafter give the values of tensile strength under certain stated conditions, and will, therefore, I hope, though in themselves not of great importance, assist in determining at some future time the average value for good qualities of some of our colonial timbers.

They do also, I think, throw some light which may be interesting, upon the ratio which exists between the strengths of the different kinds—the value, for instance, for white and blue gum being three and a half times that for messmate. An examination of the fractured specimens shows the character of the fibre, and indicates clearly that the tensile strength is highest where the fibre is straightest.

RESULTS OF EXPERIMENTS.

I. Messmate. *Eucalyptus obliqua.* Bullarook Forest.

	Lbs. per sq. in.		
a.	8500.	Broken.	Rather short fracture.
b.	8500.	Broken.	Short fracture.
c.	8200.	Broken.	Short fracture.

The wood was well seasoned, clean, but not quite free from shakes. This defect should not, however, affect its tensile strength to any appreciable extent.

II. Bluegum. *Eucalyptus globulus.* Tasmania.

	Lbs. per sq. in.	
a.	26,500.	Pulled through entirely.
b.	24,000.	Cracked, but not broken. The lever at 24,000 lbs. reached its limit.
c.	29,800.	Broken. Very long fracture.
d.	26,700.	Pulled through. This specimen was 12 in. long.

A very good, well-seasoned specimen of this wood, beautifully clean and straight in grain.

Lancewood, tensile strength	23,400
Beech	22,000

These are the highest values in the tables of Rankine and Molesworth.

III. Whitegum. *Eucalyptus.* Bullarook Forest.

	Lbs. per in.	
a.	29,700.	Entirely pulled through.
b.	28,900.	Broken. Very long fracture.
c.	25,000.	Broken. Long fracture. This last was not a fair test, as the specimen was not hung perfectly straight, and so cracked on one side before giving way.

This was a very fine, clean, well-seasoned piece of wood.

IV. STRINGYBARK. *Eucalyptus macrorrhyncha.* Bullarook.

Lbs. per in.

a. 11,700. Broken. Long fracture.
b. Stood at 14,000; entirely pulled through at 20,000.
c. 23,000. Broken. Very long fracture.
d. 23,400. Broken. Very long fracture.

The first specimen tested was probably an inferior piece.

V. BLACKWOOD. *Acacia melanoxylon.* Tasmania.

Lbs. per in.

a. 26,500. Entirely pulled through.
b. 24,000. Slightly broken; mostly pulled through.
c. 32,000. Slightly broken; mostly pulled through. This extraordinary result was obtained from a specimen of the form shown in figure 3.
d. 20,000. Broken. Long fracture. Received a jerk, on which it broke.
e. 23,000. Broken. Long fracture.

d and *e* were of a different wood from those before; much lighter in colour, more open in grain—evidently younger wood, and ill seasoned.

a, b, c, were from fine, close-grained, dark-coloured wood, well seasoned and extremely hard. *c* shows round the fractured part fibres like threads of silk.

VI. RED DEAL. *Pinus silvestris.* Baltic.

Lbs. per in.

a. 12,000/13,000. Broken. Short fracture.
b. 8,000/10,000. Broken. Short fracture. This specimen had an area of $\frac{1}{8}$ in.
c. 13,800. Broken. Short fracture.
d. 8,000/9,000. Broken. Short fracture.

VII. KAURI. *Dammara Australis.* New Zealand.

Lbs. per in.

a. 10,000/12,000. Broken. Short fracture. Specimen area, $\frac{1}{8}$ in.
b. 10,000/11,000. Broken. Short fracture.
c. 9,100. Broken. Short fracture.

VIII. REDGUM. *Eucalyptus rostrata.* Victoria.

Lbs. per in.

a. 14,000/21,500. Broken. Long fracture.
b. 16,200. Broken. Long fracture.
c. 15,700. Broken. Long fracture. The last specimen at a disadvantage, not being hung perfectly straight.

IX. CEDAR. *Cedrela Australis.* Queensland.

Lbs. per in.

a. 2000/3000. Broken. Short fracture.
b. 2500. Broken. Short fracture. Specimen area, $\frac{1}{8}$ in.

West Indian Cedar, according to Molesworth, is 5000 *lbs.*

X. IRONBARK. *Eucalyptus siderophloia.* Sydney.

Lbs. per in.

a. 26,500. Entirely pulled through.
b. 21,000. Broken. Tolerably long fracture.

The grain is not at all uniform, being much twisted in parts.

For the botanical names of the various timbers given, I am indebted to BARON VON MUELLER, the Government Botanist.

THE DIORITES AND GRANITES OF SWIFT'S CREEK AND THEIR CONTACT ZONES, WITH NOTES ON THE AURIFEROUS DEPOSITS.

By A. W. HOWITT, F.G.S.,

Police Magistrate and Warden of the Goldfields, Gippsland.

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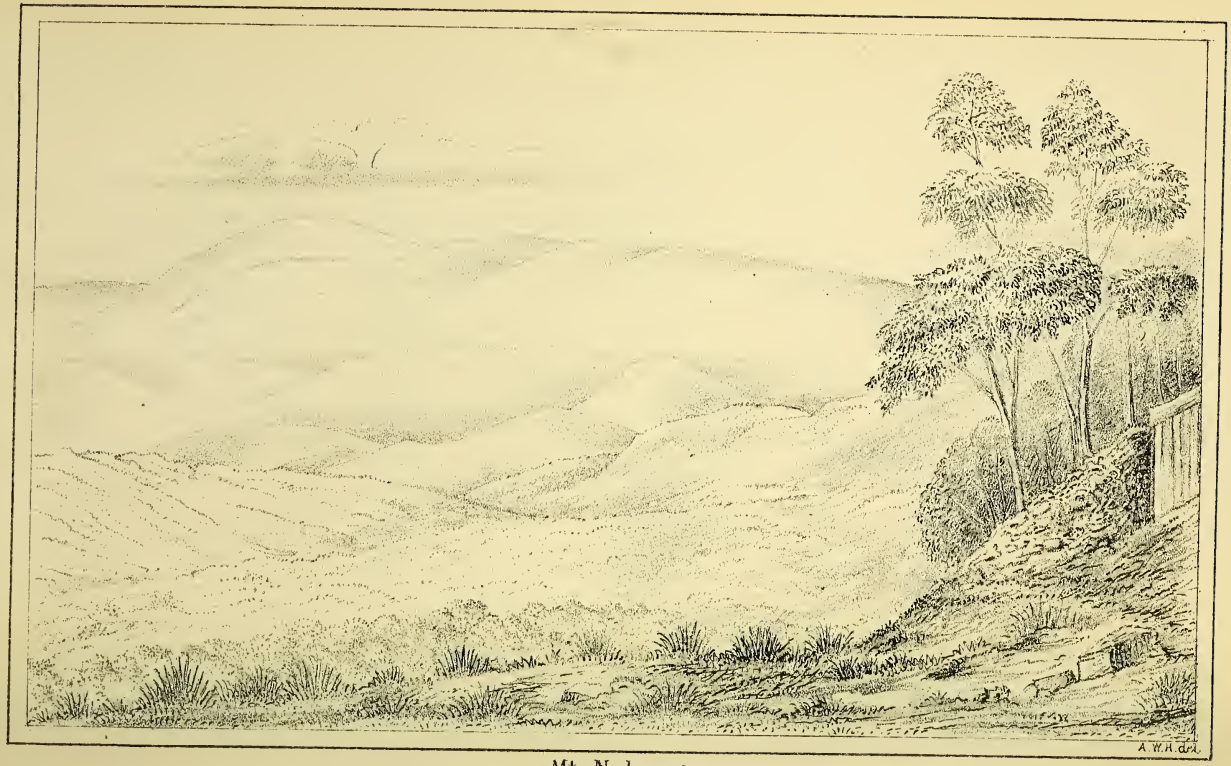
3. The Inter-relations of the Rock Masses

PART II.

4. The Alluvial Gold Deposits
5. The Auriferous Quartz Veins

General Conclusions

CENTRAL PARK
NEW YORK



~ Mt Nukong,
View from the Rob Roy Mine Eureka.

Art. III.—*The Diorites and Granites of Swift's Creek, and their Contact Zones, with Notes on the Auriferous Deposits.*

By A. W. Howitt, F.G.S.

[Read 12th June, 1879.]

Introduction, and Description of the Physical Features of the District.

It is now nearly fifteen years since my attention was first directed to the peculiar physical and geological features of the Swift's Creek District, near Omeo. During that long period I have from time to time made observations as to the rock masses found there, but it was not until five years back that I seriously set myself to the task of systematically collecting data, and of endeavouring to trace out and explain therefrom their geological history, while describing and classifying the various formations occurring at that place. Before recording the results of these observations on the geology of Swift's Creek, it may be as well to describe shortly the physical geography of the part of Victoria in which that place is situated.

If we take a general view of Eastern Victoria, we shall perceive that it consists of a vast extent of mountains, known as the Australian Alps, which are flanked to the south by lower lying tracts, stretching from the foothills to the sea, and to the north by the extensive levels of the Murray basin. The central mountain mass may be further described as being formed mainly of highly-inclined Lower palœozoic strata, on the denuded edges of which rest isolated tracts, either of upper palœozoic formations, or of Tertiary volcanic streets.

The mountainous area rises to heights of nearly 7000 feet above the sea level, and snow accumulates upon them for many months of the year. The formations of Tertiary age which fringe the mountains on each side rise on their flanks to elevations which do not, according to my measurements, exceed 800 feet above sea-level, and often fall short of that height. If we, therefore, picture to ourselves a contour line extending from the south-eastern boundary line of this

colony, near Cape Howe, westward through Gippsland, at an elevation of from 700 to 800 feet, it would define approximately the upper limit of the marine tertiaries ; or, in other words, the maximum level in respect to the mountain mass at which the sea has stood during Cainozoic time, or still more properly, it would represent the total elevation of the land above sea-level during that period. But in the latter case it would be necessary to add to that elevation of 700 or 800 feet also the depth at which the continuation of the older leads would, if traced out, emerge below the level of the sea. An extension of such a contour line round the northern slopes of the mountains would also define similar features in the Murray basin, where, however, the conditions were probably lacustrine. It is of interest to observe that this same contour line would also approximately mark a zone within which the flora—as, for instance, species of eucalyptus—differ from those met with at higher levels. From this upper margin of the marine tertiaries rise the first tiers of mountains composed of palœozoic rocks. Higher again than these commence the elevated plateaux—such as Omeo and Gelantipy, in which the rocks are mainly palœozoic, but are also in places Tertiary volcanic. The vegetation of these plateaux approaches an alpine character; the country is generally open and well grassed, and, again, marked by peculiar species of eucalypti. The grassy character of the country becomes still more predominant in ascending to greater elevations, until at about 5000 feet above sea-level the eucalyptus forests cease, and the highest plateaux and mountain summits are thickly clothed with snow-grass and alpine plants.

These mountain plateaux are a peculiar feature of the Australian Alps. An extended examination has shown me that they are the remains of a once vast tableland which stretched from Victoria far round the eastern coast of Australia, and the width of which in this colony may be roughly defined by Mount Wellington in the south and Mount Buffalo in the north. Leaving out of consideration smaller tracts—such as the summit of Mount Useful—it is evident that the high plains of Wonnangatta, the Dargo, and the Bogong, the tablelands of Omeo, Nunnyong, and Gelantipy, are connected by similar physical features, elevation, climate, and vegetation with the extensive plateau of Maneroo. These remarks, when somewhat modified, are equally applicable to the northern slopes of the mountains

and to the low-lying, probably lacustrine, deposits of the Upper Murray basin.

The district of Swift's Creek lies immediately south of the Great Dividing Range, which alone separates it from Omeo, and it may be classed with the upper part of the second and the lower part of the third zone. Swift's Creek takes its rise on a small plateau, which is scarcely more than a ledge, attached to the Omeo tableland, and falls rapidly through deeply eroded valleys to the Tambo River. This plateau is locally known as the Gum Forest. It is thickly grassed, and lightly timbered with white gum; while in the lower part of the stream the valleys are steep, with high-pointed ridges, and clothed with grass and an open forest of white box and apple-tree. Thus we have here those features well defined in miniature which I have indicated as general to the whole of the North Gippsland Mountains.

The examinations made by Mr. Reginald Murray and myself, of which the results have been published in the *Reports of Progress of the Geological Survey of Victoria*, show that during Miocene times the vast tableland which I have indicated still existed. Terrestrial conditions which have been continuous until now have sculptured the surface of that plateau as we now find it—a land of deep valleys and corresponding mountains. The volcanic portions of these highlands have been deeply excavated and lessened in extent, and during that vast period the surrounding higher points have been reduced in altitude. Thus the tableland has become separated into isolated parts of greater or less extent, and for long distances so entirely removed that a simple ridge is all that remains now, forming the Great Dividing Range.

It is evident that during these terrestrial conditions our existing alluvial gold workings of Gippsland were mainly accumulated, and that while some alluviums of age contemporaneous with or earlier than the Miocene period were sealed up in their valleys by flows of basalt, other auriferous deposits of such age suffered continuous rearrangement up to recent times as the streams gradually deepened their valleys with greater or less rapidity in accordance with the varying oscillations of the land.

The gold-bearing quartz veins in the Silurian formations, in the metamorphic schists, and, as I shall show, in the metamorphosed rocks in contact with intrusive quartz

diorites and granites, contributed to these deposits.* Some Upper palœozoic conglomerates which have been derived from those older formations also contributed, and other sources may have existed in the abraded and worn rock masses, which we cannot now point out.

Definitions of the Terms Used in this Essay to Describe the Igneous Rocks.

Felsite is a compact or micro-crystalline granular compound of orthoclase-felspar and quartz. When it contains orthoclase crystals it is *porphyritic felsite* (felspar porphyry); when it contains quartz crystals it is a *quartz felsite* (quartz porphyry); when the felspar is not orthoclase, but plagioclase, the rock is a *plagioclase felsite.*

Granitite is composed of quartz, orthoclase, plagioclase, and magnesia mica.†

Amphibole granite is composed of quartz, orthoclase, plagioclase, and hornblende.†

Diorite is composed of plagioclase and hornblende; plagioclase and magnesia mica constitute *mica-diorite.* The addition of quartz to either of the above forms a *quartz-diorite* or a *quartz mica diorite.*

Amphibolite is a rock composed essentially of more or less perfect crystals of amphibole confusedly aggregated together.

Diabase is a granular compound essentially of plagioclase and augite, to which are associated chlorite and magnetite. The term is applied to the pretertiary representatives of dolerite.

To the above is added the contact rock *aplite* or *semi-granite,* which is a granular compound of potash felspar (orthoclase or microcline) and quartz, with muscovite mica as an accessory, and, in very rare cases, plagioclase.

Note.—The crystallo-graphic notation made use of is that of Professor J. D. Dana.

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* In the New London Reef, Happy Valley, near Myrtleford, I found that the auriferous rock worked was, in fact, a very quartzose variety of hornfels. The auriferous portion could not be called a true vein, but resembled more some of the contemporaneous segregations of quartz found in the crystalline schists.

† *Rosenbusch Mikroskopische Physiographie der Massigen Gesteine,* p. 19.

PART I.

1. General Geology of the District.

In making an extended geological examination of North Gippsland—the oldest formation anywhere met with is a recurrent series of greatly inclined and slightly metamorphosed slates and sandstone, with quartz veins. These rocks vary from an almost purely argillaceous to an almost purely arenaceous composition. Slaty cleavage is always more or less present. That the strata have been greatly denuded before Upper palœozoic times, is evidenced by their extreme unconformity with these Devonian sediments, which in various localities still rest upon them. In Gippsland, as in various other parts of Victoria, it is found that the older palœozoic sediments, after being tilted, compressed, and more or less metamorphosed, have been extensively intruded into by vast granitic masses, which, on an examination of the contacts, are not found to have generally disturbed the strike of the slates as prevailing in the district, except immediately at the contact, where they have truncated, crumpled, turned back and broken up the beds. This is more especially the case when the contact crosses the strike of the sediments. In the direction of the dip the strata usually incline both against and from the granite masses; and it is also seen that, especially when the sedimentary rocks have been cut across, granitic apophyses and veins penetrate the strata, and that portions of the latter are occasionally found included in the granite, and either completely cut off from the main mass, or merely attached to it by irregular portions of strata.

This vast recurrent series of palœozoic sediments, together with the intrusive granitic masses, is in Gippsland found to be older than the Middle Devonian marine limestones, which, as at near Buchan and Bindi, rest upon the denuded surface of both. In other localities, however, younger sediments have evidently been involved in the general folding. These younger sediments are distinguished from the Lower silurian formation, not only by fossiliferous beds fixing their age* as Upper silurian and Middle Devonian, but also by the peculiar

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* *The Devonian Rocks of North Gippsland*, by A. W. Howitt. *Report of Progress of Geological Survey of Victoria*, Part III., p. 183, *et infra.*

lithological character of the sediments themselves. Such cases occur at the Limestone River, and at Tabberabbera. From this we are justified in concluding that the folding, compression, and denudation of the older palœozic sediments, which constitute the great bulk of the series of which I have spoken, has been the result of successive movements of the earth's crust extending over vast periods of time.

It may, I think, be provisionally accepted that the great series of slates and sandstones of North Gippsland, in which, to the east of the Mitchell River, are situated most of the gold-workings, is of Lower silurian age;* and it is in this portion of the district that Swift's Creek is situated. I speak of this series throughout this paper as Lower silurian, leaving to the future the determination of other local exceptions similar to those to which I have alluded.

At the Upper Dargo River the Lower silurian formations pass within a space of about two miles by the production of mica, and the segregation of silica into mica schist, and by the further accession of felspars into gneiss, and ultimately as the extreme of the series into granite.

These altered rocks constitute a well-marked series of metamorphic schists. There are no intrusive igneous rocks to which the changes I have noted may be due; and an examination of the district shows me that these changes have been the result of what has been termed regional, in contradistinction to contact, metamorphism.

I cannot enter in this paper into a consideration of the regional metamorphic schists of Omeo, and I propose to deal with them at a future time. It will now suffice to point out that, starting from the metamorphic area, the degree of change is found to decrease from some given central point until, as, for instance, at a little beyond Swift's Creek, the schists gradually pass into a series of nearly vertical slates and sandstones similar in general character to those I have spoken of as found at the Upper Dargo River. Thus, south of Swift's Creek the series again assumes at the source of the Nicholson River those characters which I have described as characterising it in the goldfield regions of North Gippsland. The crystalline schists of Omeo are the regionally metamorphosed representatives of the Lower silurian formations.

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* The only localities where fossiliferous beds have been met with are east of the Snowy River—*e.g.*, Guttamurra and Deddick.—See *Report of Progress of Geological Survey of Victoria*, Part III., p. 186.

I have observed, when tracing round the boundary of regional metamorphism at Omeo, the constant recurrence near it of tracts of intrusive granites and felsites, but as yet I have not been able to identify such intrusions within the Omeo schists themselves. So far as I have yet examined, it seems certain that all these granites and felsites are of an age younger than the Omeo schists which they adjoin, and at Bindi, where alone some Upper palœozoic rocks still remain, I have found these latter resting upon them.

It becomes, therefore, an exceedingly interesting, and as regards dynamical and chemical geology, an important question for consideration, what connection there may be between the intrusion of these igneous masses and regional metamorphism. I can now, however, only refer thus briefly to the question, and leave it for future consideration.

The intrusive igneous rocks of Swift's Creek, which I have taken as the subject of this essay, are situated exactly in the passage of the normal Silurian formation into the regional schists of Omeo, and are, therefore, an example of the above statements.

Although it can be shown that these intrusive masses are all younger than the Omeo schists, it is not easy to point out the precise period to which they belong. They are generally found protruding from the denuded Lower palœozoic formations as mountain masses, or when the sediments are hard and silicious, they form eroded basins. At Swift's Creek there are no younger formations to aid in determining the geological age. At Bindi, however, as I have said, at a few miles distance there is a similar occurrence of intrusive igneous rocks which is overlaid by Devonian sediments.* In this instance, therefore, the age is fixed as between the close of the Silurian and the middle of the Devonian periods. Elsewhere similar intrusive masses as Mount Taylor, near Bairnsdale, are found capped by Upper Devonian beds.† The Swift's Creek granites and diorites are, in fact, part of that rock formation of North Gippsland upon which the Upper palœozoic sediments were laid down.

**Report of Progress of the Geological Survey of Victoria*, Part IV., p. 158, *Schedule of Report on Fossil Specimens*, by Professor M'Coy, Nos. 4083 to 4131.

†*The Devonian Rocks of North Gippsland*, by A. W. Howitt. *Report of Progress of the Geological Survey of Victoria*, Part III.; also, *Schedule of Reports on Fossil Specimens*, by Professor M'Coy. *Progress Report G. S. V.* Part IV. No. 2687, p. 155, and No. 3295, p. 156.

(2) Mineral Composition and Classification of the Rocks.

In attempting a description of the mineral composition of the various rock masses met with in the district I am describing, it becomes necessary to begin by a division of the rocks into sedimentary, regional metamorphic, igneous (intrusive) and contact metamorphic, and it is in this sequence that I shall consider them.

(a.) The Sedimentary Rocks.

This class is represented in the area described only by a small tract of yellow and green slates and quartzose sandstones, in the south of Riley's Creek, and by a narrow zone of indurated slates and sandstones lying outside the rocks in immediate contact with the intrusive diorites and granites. These indurated sediments approach the character of the normal Silurian rocks, of which they are, I doubt not, part. In them the effects of alteration are not so far advanced as to remove them from the category of the sedimentary into that of the metamorphic rocks. The examples examined were collected at Tongeo West, Swift's Creek, where they pass on the one side into the hornfels group, and on the other into nodular argillaceous schists, which are there the least metamorphosed of the Omeo series. The changes which are observable in these indurated rocks are to a great extent parallel with those which I have noted in a series of slices prepared from the passage rocks, which connect the normal Silurian slates and sandstones with the regional crystalline schists at the Upper Dargo River. The normal argillaceous slaty members of the series, for example, are seen to be more or less permeated by a pale green to almost colourless silicate, which in places forms distinct flakes or small patches. In more altered examples there are more numerous flakes, and also somewhat short and stout but often ragged fibres of similar character. The most complete change is found in those rocks which precede the distinctly micaceous beds, in which the ground mass of the rock appears to be a colourless transparent mineral in scales or flakes, which are doubly refracting and suggestive of kaolin; and throughout this groundmass there are many—often extremely numerous—pale green interlacing fibres, apparently the representatives

of the previously remarked diffused silicate. These suggest chlorite, and so far as can be observed of such microliths, become dark when their longer diameter accords with the polarising plane of either of the crossed nicols. The change in the Swift's Creek passage rocks, or least altered of the contact schists, very strongly resembles that seen in the Upper Dargo passage rocks. The ground mass consists of minute, colourless, transparent, overlapping scales or flakes, probably orthorhombic, and in this, either irregularly disseminated or lying parallel to the bedding, are great numbers of pale green to almost colourless, rather stout, and usually bent and twisted fibres. So far as it is possible to speak with any certainty of such microliths, it seems to me that they become obscured when their longer diameters are parallel with the plane of polarisation of one of the crossed nicols. It seems to me, therefore, probable that the rock-forming materials of these argillaceous strata have become rearranged as two distinct silicates. In the absence of a quantitative analysis of the rock, it is not possible to speak with any certainty; but assuming that these Silurian slaty rocks have a composition similar to that of such rocks elsewhere, and which have been analysed, the idea is not unreasonable that in the colourless, probably orthorhombic, scaly silicate we may recognise a mineral allied to kaolin, and in the pale-green, stout, twisted fibres or plates, a magnesian silicate allied to chlorite. Besides these component silicates there is some amount of amorphous, black, opaque material, unaffected by hydrochloric acid, which may probably be carbonaceous.

Throughout these rocks strings and lenticular groups of quartz grains, as also contorted veins of quartz containing the chlorite fibres (?), indicate metamorphic action.

Classification of the Sedimentary Rocks.—It is not necessary to say much as to the classification of these rocks. That they are sedimentary in origin is shown by their position and structure in the mass. Their probable geological age is indicated by the general considerations to which I have already referred; and the microscopic examination shows that they are the indurated representatives of rocks, such as the fine-grained aluminous slates and the quartzose sandstones of the Silurian formation of the district.

(b.) The Regional Metamorphic Rocks.

The regional metamorphic schists which are found on the north and west side of Swift's Creek include, I believe,

almost the whole series, from silky, wrinkled, argillaceous schist to granite. To deal with all such schists as occur within the area I have mapped would be, in fact, to open up the whole question of regional metamorphism, and this is outside the scope of the present paper. I have, therefore, only examined those nodular, argillaceous, and quartz schists which form the fringe of the regional metamorphic area.

In speaking of the component minerals of these rocks, I must include the ill-defined substance which I have already spoken of as forming the main mass of the slaty rocks and the cement of the sandstones.

In a slice of the nodular schist from Swift's Creek, examined under the microscope, the ground mass is entirely composed of plates of mica, which are approximately parallel to each other. As, however, the foliations of mica are more or less contorted, the aggregations of mica plates seen in the thin slice are discordant; some are flat, and some on their edge. The mica plates envelope the nodules, and are, where nearest to them, rather smaller than elsewhere. In treating a thin slice of this rock with concentrated hydrochloric acid for several days, the only perceptible effect was the removal of much iron by which the rock was stained. Among the colourless mica, which I regard as muscovite, are numerous flakes and groups of flakes of dark-brown magnesia mica. These flakes are approximately rhombic in form, are strongly dichroic, although not, perhaps, in so marked a manner as is much of the magnesia mica of the diorites.

There are throughout all this ground mass innumerable minute, thorn-like, dark-brown to black microliths, which cross each other and interlace in the utmost confusion. I observed that the greatest numbers were associated with the magnesia mica rather than with the potass mica. These microliths have often ragged or brush-like terminations, and suggest that they may be built up of a number of fibres. I am unable further to determine what they are, owing to their minute dimensions, but it has seemed to me possible that they may belong to amphibole.*

I have observed several instances of alternation of laminæ of potash and of magnesia mica, and also frequently the inclusion of minute plates of the former in the latter. In the muscovite of the ground mass I observed minute cavities,

* See Zirkel *Mikroskopische Beschaffenheit der Mineralien*, 1873, p. 491.

apparently containing fluid, and also very minute colourless rectangular crystals which I could not otherwise determine.

The nodules contained in the ground mass have the same constitution, but their structure is exceedingly minute. When the edges of the slice are very thin it is possible to make out that they are composed of minute rounded plates of some colourless mineral, having a micaceous structure. This mineral is unaffected by hydrochloric acid. In the ground mass of the nodules the magnesia mica is also developed in isolated aggregates of slightly overlapping laminæ, which are irregularly rounded when seen in the direction of the prismatic axis, but irregularly rectangular across it. They are dichroic, and in several nodules which I examined I found them arranged with the prismatic axis parallel to the shorter diagonal of the nodules.* With these there are also long and narrow flakes of muscovite, and, as before, I found here minute flakes of it embedded in the magnesia mica. In the ground mass there are many minute black opaque and amorphous masses which are probably a form of carbon.

A most interesting, and at the same time puzzling, observation is the frequent occurrence of spheroidal or elliptical cavities, having all the appearance of vacuities—namely, a wide, dark margin and a central spot of light. I have felt much doubt whether these vacuities may not have resulted from imperfect mounting; but as I observe them in almost all the nodules, I have concluded that they may be natural. According to some measurements they are ·0005 inch in diameter. I am unable at present to account more fully for them.

The nodules are portions of the rock mass which have not undergone the complete change to which the remainder has been subjected. They are less crystalline than the ground mass.†

Classification of the Schists.

The examples of these rocks are so few, being only taken from the nodular argillaceous and the quartzose members of the group, that few words are required. An examination in

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* Further examination has shown me that by digestion with warm hydrochloric acid the brown pigment (iron) is removed in a great measure from these nodules. The dichroic mica becomes perfectly colourless, and it only differs in form and in its small optical angle from muscovite.

† Professor Rosenbusch points out similar changes. See *Die Steiger Schiefer, &c.*, Strassburg, 1877, p. 256.

the field suggests that which the microscopic analysis confirms —namely, that they are nodular argillaceous schists and quartz schists; in fact, those members of the regional metamorphic series which are found in many localities near Omeo in the outer verge of the regionally metamorphosed formations.

On the one hand, they are found, as at Swift's Creek, to pass by increasingly altered examples into the true mica schists and gneiss, and on the other by less altered examples, as would be the case at Swift's Creek did the intrusive masses and their contact zones not intervene, into the normal Silurian slates and sandstones.

(c.) The intrusive igneous Rocks—their component Minerals.

The rocks of this class form, as a whole, a great intrusive mass of about 30 square miles in area. They are surrounded by a zone of contact schists, are flanked in the east, north, and west by the regional metamorphic, and in the south by the more or less normal Silurian formations. These intrusive igneous rocks are compounded of various minerals, and it is in accordance with their co-occurrence that the rock masses must be classed. I now proceed to examine their individual mineral constituents, and to record my observations.

The Felspars.

It becomes of great importance, in classifying the felspars, to attempt, if possible, to fix upon some optical characters of sufficient constancy to serve as standards of reference. Such constant characters have been indicated by Des Cloizeaux,* and are frequently referred to by Rosenbusch.† The former states that in thin plates of albite, parallel to the basis, the plane of the maximum obscuration forms an angle with the composition face of 3° 50′ to 4° 50′; in oligoclase that direction is almost parallel to the composition face; in labradorite, the angle is 5° 17′ to 6° 58′, and in anorthite 20° to 40°, when the plate is

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* *Comptes Rendus*, lxxxii, 1876; and abstract *Nenes Jahrbuch für Mineralogie*, 1876, p. 658.

† *Mikroskopische Physiographie der Massigen Gesteine*, 1877, p. 14 *et infra.*

parallel to the basis; or in the latter 33° to 46° when it is parallel to the brachypinacoid. He states further that in the triclinic potass felspar microcline the same optical angle is 15° 30′, while in orthoclase the direction of greatest obscuration in basal sections is parallel to the edge formed by the basis and the clinopinacoid.

In order to test these statements I have prepared, and also procured from Germany, a number of slices taken in the direction of the basis and of the lateral pinacoids from both the monoclinic and triclinic felspars. I have, besides making observations upon these type specimens, also measured the required optical characters of all those sections of felspars, which appeared suitable in several hundred thin slices in my possession. The result has been to assure me that these characters may be provisionally used for the classification of the felspars, and to hope that further investigations will give to this method of examination still greater precision and reliability. Following out the indications given by Des Cloizeaux, the following is the standard of comparison which I have used:—

1. Albite and oligoclase: inclination of the optical section in zone o—$\overline{\text{ii}}$ to the edge o—$\breve{\text{ii}}$, 0° to 20°.

2. Labradorite and anorthite: inclination of the optical section in zone o—$\overline{\text{ii}}$ to the edge o—$\breve{\text{ii}}$, 6° to 30° and 20° to 45° respectively.

3. Microcline: inclination of the optical section in the zone o—$\overline{\text{ii}}$ to the edge o—$\breve{\text{ii}}$, 10° to 16°.*

4. Orthoclase: inclination of the optical section in the zone o—ii to the edge o—$\grave{\text{i}}$i, 0°.

In endeavouring to apply practically these indications, it is evidently necessary to measure these sections only which are perfectly, or nearly, in the zone o—$\overline{\text{ii}}$, if triclinic, or o—ii, if monoclinic. In those cases where there was not a perfect accord, the discordance not being greater than 3°, I have taken the mean. By these observations I have found myself enabled to class the felspars I have examined under four heads, as above. I now proceed to consider these classes more particularly.

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* The angle 10° in slices parallel to $\overline{\text{ii}}$ is approximate only.

1. *Albite and Oligoclase.*

Rocks containing felspars, whose angles of maximum obscuration in the zone o—$\bar{i}\bar{i}$, as against the edge o—$\breve{i}\breve{i}$, point to the above, are found at Lower Riley's Creek, near the Long Gully Gap, at Upper Swift's Creek, and at Eureka.

The principal point to be noted in these felspars is that they are usually compounded of very numerous narrow or alternately narrow and wide laminæ. They occur either as well-formed prismatic crystals having plane or compound terminations, or of much larger size, in which case they are less well defined.

As to the mode of composition I note as follows:—

1. Simply compounded of many alternating laminæ (albite law).

2. Doubly compounded, each half being as in 1, composed of many twin laminæ, or one-half thus compounded, while the other half (right or left) is plain. In this case we may suppose that the compounding has followed two laws—first, that of "axis of rotation normal to $\breve{i}\breve{i}$;" and, second, that of "axis of rotation parallel to $\breve{i}\breve{i}$;" or, to use expressions which will be very convenient for the purposes of this essay, according to the "albite" and "carlsbad" laws. More rarely there are cases in which the crystals consist of two pairs of twins compounded as above, thus forming a quartet. A third law may there be regarded as being followed—namely, the "pericline law," where the axis of rotation may be considered as the macrodiagonal.

The irregularities of twinning consist principally in the presence of isolated laminæ, or of small associated twin laminæ in otherwise plain sections. In some instances there are also single laminæ across the general composition. In other infrequent cases I have observed a twin dissimilarly compounded, having, for instance, the right half plain and the left half twinned (pericline law) in a direction perpendicular to the composition face.

Together with these undoubtedly triclinic felspars there are many sections which show no trace of twin composition. Some may be orthoclase, but there are others whose outlines are not rectangular but rhomboidal, and yet in which the direction of greatest obscuration is parallel to the larger side. This, I think, directly points to oligoclase; and where such sections are associated with twinned felspars

whose optical sections do not form angles above 20° in the zone o—$\bar{i}i$, the probability becomes strengthened that the former are sections of oligoclase crystals taken parallel to $\breve{i}i$.

In the measurement made of these felspars I find the angles 0°, 6°, 13°, 15°, 17°, 18°, 20°, to be of most frequent occurrence.

It is of interest to note the association of other mineral constituents with this group, and on this point I have endeavoured to gain information by carefully tabulating my data. The results are, of course, only approximate, and as such I give them; in fact, merely as suggestive of the probable truths.

I selected thirty-two slices which I regarded as fairly representing the crystalline granular igneous rocks collected. But in this collection I must note that the granitites and amphibole granites are in a minority, as they did not attract my attention so strongly by their contact phenomena or their auriferous character as did the diorites. Of these I found four in which the predominant felspar came within the requirements of this class. With it were associated subordinately labradorite, mica or hornblende, and quartz.

2. *Labradorite and Anorthite.**

These felspars are found most commonly in the felspathic diorites along the south margin of the intrusive area in the Gum Forest; especially, however, at Riley's Creek and at the Sheep Station Creek Gap. They are usually associated with a little hornblende, or mica, or both, and more rarely with quartz.

Felspars, whose angles of obscuration point to albite or oligoclase, are entirely subordinate where these occur, excepting in one locality near Eureka where I have met with rocks in which the felspars of this group and the former were in nearer proportion.

As the more acid felspars of group 1 increase, so does the percentage of quartz increase in amount in the rock. I have only observed two instances where felspars having the optical angles of this group occurred in company with a preponderance of microcline or of other tricline felspars.

The compounding and general structure of these felspars

* Andesine has been omitted, but there are measurements which cover that species.

are peculiar and interesting. The compound individuals are often seen to be well crystallised; but also, on the other hand the converse is frequently the case.

In some slices the larger individuals are all of imperfect outline. But in all cases the structure is either highly compound or irregular.

The compounding takes place almost always according to three laws, and the lamellæ are disposed most irregularly. The two halves of the twin are rarely even approximately the same in mode of composition. Instances of such structure are given in Figs. 1, 2, 3, 4.

The peculiar structure of these felspars, their broad bands of vivid colour by polarised light, and their optical characters, sharply distinguish them from those of the first group, which, as compared to them, is characterised by regularity of structure.

In this group the smaller individuals are usually most completely formed; but there are many cases where these felspars are only twinned granules, similar in character to the instances figured Nos. 7, 8, 9, 10.

As examples of well-formed crystals I give Figs. 5, 6. The latter is a good illustration of the concentric and not always concordant growth of these felspars.

The rock at Sheep Station Gap, which is mainly composed of these felspars, is almost wholly decomposable in fine powder by cold concentrated hydrochloric acid. In order to apply further tests in the absence of a quantitative analysis I did as follows:—A slice taken from the very felspathic rocks just mentioned showed me only well-marked felspars of this group having angles of obscuration of from 30° to 45°, and with all the peculiarities of structure which I have noted.

I placed this slice for eight days in cold concentrated hydrochloric acid. The felspars were attacked, and became entirely opaque and cloudy. No striations were then visible by polarised light; but there were in two or three cases unstriated or slightly striated margins which had perfectly resisted the action of the acid. There were also a few small felspars in the mass equally unaffected, and in one of which I observed the optical section to be parallel to the longer diameter. These observations point to the felspars being mainly anorthite, with albite or oligoclase, either forming a margin to the former or occurring alone as small crystals. Of the thirty-two selected examples I found twelve in which

the predominant felspar belonged to this class, and of these seven pointed to anorthite. The associated felspars with anorthite were labradorite, oligoclase, or even rarely albite; there was usually hornblende, and less frequently mica. Very rarely a colourless pyroxene (diopside) occurred. In only two cases I found quartz. In the five slices in which labradorite probably predominated, the associated felspars were oligoclase and albite, together with hornblende, mica, and quartz.

3. *Microcline.*

Felspars which I have classed thus are found in rocks at the lower part of Riley's Creek, at the Long Gully Gap, at the extreme source of the Sheep Station Creek, and at Eureka—that is, in the quartzose diorites and the allied amphibole granites adjoining the contacts.

The structure of these felspars is usually most irregular, but of an irregularity differing completely from that of group 2. It is an irregularity of structure, both physical and optical. I find these felspars most frequently as crystalline masses of irregular outline, and of larger extent than any of the individuals of the two other groups. It is common that individuals are built up of various incongruous portions, and yet form a whole. Thus, in an example which I give from Riley's Creek (Fig. 11) I found that the imperfectly shaped crystal was composed of three unconformable portions, of which one part was not striated, but had only lines of zonal growth.

In some cases the crystal is composed of two halves (Carlsbad law), one of which may be plain, while the other is striated.

In some cases the crystal is a single individual, but then almost always showing lines of growth.

In other cases, as in a slice taken from a rock at Riley's Creek, I observed, besides these instances which I have noted, where the twin (Carlsbad law) is plain as to one-half and striated as to the other, instances where in a simply compounded individual (albite law) the striations only extended partly down the crystal, and then passed almost insensibly by a curiously-mottled band into the remainder, which was unstriated.* In a somewhat similar example I have

* It must be fully understood that when I speak of the striation or of the optical character of the felspars, polarised light is implied.

observed the striated part to surround a central curiously-mottled and unstriated space. In this case I have noted a cross-banded structure, which is of common occurrence. I give in Fig. 15 a well-marked instance of this characteristic mode of composition.

These felspars do not, as a rule, polarise with those brilliant colours which are seen in groups 1 and 2; but on being rotated between crossed nicols the unstriated and mottled portions, or what may be said in some cases to be the mass in which some few twin lamellæ are situated, shows a peculiar bluish or brownish satiny sheen, which I have found to be highly characteristic of these felspars.

Cleavage is not often observable with any distinctness in these felspars, and their physical structure is otherwise peculiar. Many cases occur where they are fractured—the parts separated, and perhaps cemented together by ground mass. As a rule, they are well preserved, and rather glassy in appearance.

The only inclusions which I have observed are apatite prisms, and needles. The alterations are not great, and have principally produced kaolinisation, and only more rarely mineral aggregates of the mica group. Many of the minute cracks traversing these felspars are the depositories of infiltration products—such as ferric-hydrate.

There are, therefore, among these felspars those which are wholly twinned, or partly twinned, and those which are simple. The angles of obscuration referred to the composition face in slices approximately in the zone o $\bar{\bar{i}}$, when the individual is compound, are under 18°, and most frequently 14°, 15°, 16°, while in the simple portions the direction of obscuration often conforms with the edge o—$\breve{i}$, supposing the crystal to be triclinic or o—$\grave{i}$, supposing it to be monoclinic. These angles do not agree with the triclinic soda and soda lime felspars, nor with orthoclase.

Des Cloizeaux has pointed out* that the triclinic potash felspar microcline is sharply marked by its characters. A slice parallel to the basis shows the direction of obscuration inclined to the edge o—$\breve{i}$ at 15°—16°, instead of being parallel to it, as in orthoclase. Many of the microcline group—as, for instance, Amazonstone—are distinguished by two systems of

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* *Comptes Rendus*, lxxxii., No. 16; also see Rosenbusch *Mikroskopische Physiographie der Massigen Gesteine*, 1877, p. 14.

lamellæ, whose intersection is nearly perpendicular, and in which the alternate lamellæ are twins. This structure of microcline produces a highly characteristic cross-banded appearance by polarised light.

The observations which I have made on these triclinic felspars entirely accord with the above, and although a quantitative analysis of the rock is still required, I feel that I may with some little confidence refer these felspars, as I have done, to microcline. I shall have to point out later in this essay that the felspar composing one of the contact schists is without doubt a triclinic potash felspar, and that it agrees optically with the above requirements of microcline; it also agrees in its character with the felspars, which are components of those rocks which adjoin the schist.*

The inclusions in these felspars are few in number as in species. Apatite in small colourless prisms and needles is the most frequent. In some few cases I have observed microscopic flakes of magnesia mica, or of amphibole, and also minute, colourless, rather stout prisms, whose terminations suggest a monoclinic habit. Very rarely I have observed what appear to be octahedral crystals of magnetite. Besides these, which may be regarded as original inclusions, there are also frequently flakes of chlorite and patches of iron ores, evidently the result of alteration and infiltration.

The alterations which these felspars have undergone are of two kinds, of equal frequency of occurrence—kaolinisation and micacisation. In both cases the change has mostly commenced from the centre and extended outwards along the cleavage planes. But occasionally I have observed that some lamellæ have been more affected than others. When the felspar has been kaolinised it becomes grey and cloudy, and loses its characteristic chromatic polarisation, without

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* I may note that I have, as yet, failed to isolate these felspars. As an instance, I may take the following :—I obtained a fragment from the perfect cleavage of a crystal apparently of this felspar in one of the coarse-grained samples which had afforded me a characteristic thin slice. From part of this I succeeded in preparing a microscopic object; the other part I examined before the blowpipe for potassium. The microscopic examination proved it to be not striated, and that the direction of obscuration was parallel, or nearly so, with the edge o—$\bar{i}\bar{i}$ (supposing it to be triclinic). The portion examined chemically gave only a very slight precipitate of chloride of platinum and potassium. Before the blowpipe I could not detect potassium with any certainty by observations of the flame reaction through cobalt glass. The above experiments point, I think, to a simple crystal of oligoclase.

acquiring any other marked character. When the felspar has been converted into a micaceous mineral the result is an aggregate of minute twisted and crumpled, colourless plates, which with crossed nicols polarise with much colour. When these flakes are more regular and somewhat of larger dimensions than usual I have been able to observe that they narrowly resemble muscovite. As, however, both the potash and the soda lime felspars are similarly altered, the idea suggests itself that the resulting mineral may be either a potash, a soda, or a lime mica, according to the constitution of the felspar. This micaceous alteration may be observed in every stage, from a small central aggregate of mica scales to the complete conversion of the whole felspar crystal.

4. *Orthoclase.*

The monoclinic potash felspar is found in rocks in that part of the area east of the Gum Forest where the granitic rocks are the representatives of the intrusive masses. It is also found in the quartzose diorites of Riley's Creek and Swift's Creek as a subordinate constituent.

It is rarely well crystallised in the quartz diorite, but generally occurs as irregularly bounded masses or imperfect crystals. In some cases it forms a more or less essential part, and thus causes such rocks to approach in character to the granitites and amphibole granites of the fall to the Tambo River in which it predominates. It is more subject to alteration than the triclinic felspars (including microcline), and the alterations are to kaolin as well as to mica.

Inclusions are rare, and confined almost to apatite and to a little magnetite. As the diorites become more basic in constitution, orthoclase decreases in amount, until, as in the anorthite diorites of Riley's Creek and in the amphibole-gabbros of the Gum Forest, it is entirely absent. I have found it always associated with quartz, with either hornblende or magnesia mica, or with both together, in company with the felspars of groups 1 and 3.

In addition to these rock-forming felspars, I have met with one which is a constituent of a mineral vein at Power's Reef, near Eureka. This reef is immediately in the contact, and the vein mentioned passes through the quartz diorites, and consists of two felspars, quartz, and broad plates of dull-green magnesia mica. One felspar is pale flesh-red, and has all the appearance of orthoclase. The other is

milk-white, and in it, so far as I could observe in the absence of measurements, the two most perfect cleavages are not quite perpendicular to each other. The basal cleavage reflects light in numerous planes very slightly inclined to each other. The lustre in this cleavage is slightly more pearly than in orthoclase. Samples examined before the blowpipe gave strong potassium flame and moderate sodium flame reactions, and a quantitative examination showed a considerable amount of potassium. Pieces from the basal cleavage, examined as thin slices, proved to me that this felspar varies much in structure. In one example, half, at least, shows the usual characters of orthoclase in which the internal structure is not quite homogeneous. The other half is traversed by irregular bands of triclinic felspar, in which the composition face is across the direction of the bands. The angle of obscuration in these bands is from 2° to 3° on each side of the composition face. The portions alternating with these bands of triclinic felspar become obscured in a direction, according to my measurements, which were not quite satisfactory, of 14° against the edge o—ii, supposing the felspar to be orthoclase. This ground mass is always more or less cross-banded, precisely in the manner of Amazon stone; and where this structure was well developed, I obtained some measurements of the angle which gave me 15° 30′. This indicates microcline.

A second piece, prepared from a sample which had the discordant cleavage planes on the basis, showed me that the whole was traversed by very narrow and somewhat faint lines of twinning. In places, however, where I could obtain measurements I found that portions became obscured when the plane of polarisation of one of the nicols was parallel to the composition face, while other lamellæ required to be rotated over an angle of 3° with that direction before becoming obscured. These observations indicate that the first example has the structure of perthite, with this difference, that potash felspar is in its triclinic form. The second example appears to consist of alternating lamellæ of albite and orthoclase.

A sample of the pale red coloured felspar prepared from the basis showed only the cross-banded structure characteristic of microcline.

This felspathic vein is one of a numerous class which occur in the Omeo district, traversing the crystalline schists.

They belong to the "endogenous granite veins" of Dr. J. S. Hunt. They, almost without exception, have this cross-banded or twinned variety of sodiferous potash felspar.

It was, I think, formerly assumed that the triclinic felspars which are constant constituents of the granites, belonged to oligoclase. This also applies to the triclinic felspars of the quartz diorites, their near allies. It was also generally assumed that two or more of the triclinic felspars did not occur together in any one of the igneous rocks. These views have gradually been abandoned. Indeed, if we accept Tschermak's theory that the various felspars, albite, oligoclase, andesine, labradorite, anorthite, are, in fact, but an iso-morphic series, of which the second, third, and fourth are admixtures of the first and last, there can be no real difficulty in accepting as probable that any two or more of them might occur together, in accordance with the various proportions of potass, soda, or lime in the original magma. Assuming the correctness of Des Cloizeaux's statements, and that the observations which I have made are reliable, we have, then, proof in these Swift's Creek rocks of such simultaneous occurrence. I have pointed out the general groups into which I have found it possible to collect the felspars, and these groups probably include the whole series. I observe that in the series, orthoclase, microcline, albite, oligoclase, anorthite—taking these five as an illustration—the more basic the felspars are, the less free quartz is associated with them in the rock. It becomes evident that in the quartz diorites of a very granitic character, microcline in a great measure represents the triclinic forms. It is associated not only with its then subordinate monoclinic form, orthoclase, but also with those felspars, the inclination of whose direction of obscuration to the composition face point to albite or oligoclase rather than labradorite or anorthite.

All these and other considerations have led me to see that our usual view of the felspars will probably undergo considerable modification. We can no longer view them as a group of distinct species, but as forming a series of iso-morphic mixtures of certain double silicates of alumina and alkali, or lime, or baryta, in which some particular ratios of the components most frequently occur. It is, in fact, only in accordance with the theory of the felspars as propounded by Tschermak that a comprehensive view of the whole group becomes possible. He has shown that the triclinic felspars are iso-morphic silicates of alumina and alkali, or of alumina

and lime, or baryta. The felspar in which the alkali is potash, is as orthoclase monoclinic, while as microcline it is triclinic. The felspar in which the alkali is soda is only known in its independent form as the triclinic albite. But the admixture of soda which is constantly found in varieties of orthoclase, such as adularia, in which it evidently does not exist as an intergrowth of albite, proves that in these cases it must be present as an iso-morphic mixture, and we have then the soda felspar albite in its monoclinic form. Similarly the small percentage of lime in orthoclase, or of potash in albite, or in anorthite, points to iso-morphic admixture of the potash, soda, and lime felspars. The baryta felspar is not known in independent existence, but hyalophane "is a mixture of potash felspar with that barium compound which in its composition is the analogue of the lime compound anorthite."*

These facts indicate that the whole of the felspars are an isodimorphic series. Such series are not rare in nature. I may instance the anhydrous carbonates of the iso-dimorphic calcite and aragonite groups.

Amphibole.—Throughout the whole area examined amphibole in some variety forms an essential constituent in the majority of the examples which I have collected; but in the central and southern parts of the great intrusive mass it occasionally predominates to the exclusion of almost every other mineral. In forty slices which I have taken as representing the general composition of the intrusive dioritic masses, I find that it occurs as an essential constituent in nineteen. In two of these it forms almost the whole bulk of the mass; in six it is merely accessory to the magnesia mica, and in five it is absent; in three cases only does it occur in rocks devoid of free quartz. I find it in these examples to be associated with the felspars of groups 1 once, 2 seven times, 1 and 2 ten times, 3 and 4 nine times, and 1, 2, 3, and 4 once—thus showing a slight preference for the lime and soda lime felspars rather than the potash felspars.

Amphibole occurs in more than one variety. In the granitic quartz diorites it is in more or less ill-defined, short, prismatic crystals, or in irregularly shaped plates; in those

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* *Tabellarische übersicht der Einfachen Mineralien, &c.* P. Groth, Braunschweig, 1874. I am under many obligations to this admirable review of the mineral kingdom.

more basic rocks, of which it forms a large ingredient and wherein quartz is absent, it occurs either in ill-defined prisms or in large crystalline masses which often have a predominant cleavage apparently in the direction $\bar{i}\bar{i}$. The colours and structure of these two varieties also differ. The former are often glassy in appearance, and yellowish or dark-green in colour; the latter are in shades of green, often very pale, and in some cases redish-brown. In the latter it is almost invariable that they include exceedingly numerous, imperfectly-formed crystals of plagioclase, whose outlines are usually rounded as if from incipient re-solution. There are also numerous spheroidal masses of what seem to have been "ground mass."

It is almost always possible to trace prismatic cleavage in some of the sections across the prism, excepting in those crystalline massive varieties which form almost the whole rock mass, and in these it is often very obscure, or even absent. I shall refer to this again in describing the extreme form of this rock. In all cases which I have observed, even in those which depart most from the usual appearance of hornblende, the slices are dichroic, and this character decreases with the diminution of the depth of colour and with the increase of the angle of obscuration of the slice. In those varieties which are crystallised in more or less well-marked prisms, and which are glassy in appearance and somewhat dark in colour, the angle of obscuration, according to a number of measurements in slices approximately parallel to $\grave{i}i$, were from 11° to 16°; while in the second class of amphibole, which was usually in plates or in crystalline, cleavable masses, having lighter tints of colour, the angles measured were very high, being from 17° to 30°. These angles, the faint dichroism, and the marked cleavage in the ortho-diagonal direction, would lead to a suspicion of diallage, but in many cases I was able to observe the prismatic cleavage of hornblende. In the former class twinning, according to the usual hornblende law, was not very frequent; and I found one instance where there was no trace of the prismatic cleavage, while yet the prism itself had the angles of hornblende, and not of augite. In the second class of amphibole, twinning is still rarer. Among the few peculiarities of structure to be noted is one which I have frequently observed in the hornblende of other rocks—as, for instance, of the hornblende porphyrites of Bulgurback.

It is that in many of the prisms there is a nucleus of what I believe to be crypto-crystalline ground mass, round which the hornblende individual has crystallised. This is, therefore, quite different to those inclusions of small spherules of ground mass which so often are seen in the massive cleavable varieties.

The principal inclusions in these two varieties of amphibole are prisms of plagioclase and crystals, and masses of magnetite and pyrite, and more rarely flakes of magnesia mica. The included felspars are usually of very abnormal structure, the twinning taking place in unusual modes. The crystals are usually imperfect, the edges rounded, or the sides unequal in dimensions. There may be only one, or, again, a considerable number of striations, and these striations are sometimes not continuous throughout the slice, or may be confined to one-half, or be of different directions in each half, or finally be represented by imperfect laminæ or flakes only. Many of these felspars have undergone serpentinous (?) alterations, together with or independently of the hornblende. There are other inclusions which I am unable to identify with anything else than portions of crypto-crystalline ground mass, which has been included. As I have said, these latter are often present as cores of hornblende prisms, and then are found usually to conform to the rhombic outline of the cleavage.

The most usual alterations to which the hornblende has been subjected is to some form of chlorite. The first appearances of change are that the edge of the hornblende becomes ragged and fibrous. The fibres are dichroic, in shades of pale-yellow and bright emerald-green. In further instances the hornblende is found to be wholly changed, with the exception of a small portion, so that by such various instances we are led to perceive the origin of similar masses of chlorite where no traces whatever of hornblende remain. In order to determine whether this chlorite is fibrous or scaly, I have carefully traced round those examples which occurred in the margins, and, therefore, in the thinnest part of the slices, and I have there observed that the chlorite fibres are approximately paralleled, are not of equal length, and are, therefore, overlapping. In places the observations suggest that these fibrous appearances are due to the sections being across plates or scales having a fibrous structure; and the very thinnest portions, examined with a high power, appeared, indeed, to consist of minute pale-green

and translucent twisted fibres.* In one slice I found somewhat larger plates of this mineral, of a darker green colour, and so situated that I was enabled to make stauroscopic observations, from which I inferred that it was certainly uniaxal. I therefore conclude that this alteration is chlorite, and have thus spoken of it. It is easily decomposed in the slice by warm hydrochloric acid.

In the production of these masses of chlorite the original form of the hornblende becomes totally lost. These observations lead me to doubt whether any of the masses of chlorite which so frequently are found filling in spaces and lying between various constituents are in any case contemporaneous constituents of the rocks, but rather in all cases derived from the alteration of amphibole, and more rarely, as I shall point out, of magnesia mica, as well as still more rarely of pyroxene.

The production of chlorite has in all cases also given rise to the elimination of ores of iron which have been deposited either in the cleavage of the chlorites, or in cleavage or flaws in the neighbouring constituents, or between them.

A second form of alteration I have observed to arise more frequently in the second variety of amphibole. It much resembles in appearance the talcose pseudo-morphs after hornblende which I have obtained from an amphibolite dyke near Omeo. The extreme forms of alteration in the Swift's Creek rocks have much similarity to serpentine. The first appearances are a lessening of colour, the production of a fibrous structure, and the deposit of iron ores. Further changes result in an aggregate of brightly polarising particles, irregularly or divergently disposed. Figs. 21, 22, are given as illustrative of the above statements.

Amphibole-anthophyllite.—This mineral is of only local occurrence at the Gum Forest, where it forms almost the whole rock mass. It extends over many acres of ground. It is crystalline massive, of a dark green colour, showing a perfect cleavage in one direction, having a metalloid and somewhat vitreous lustre. Under the microscope, by ordinary transmitted light it is green, or more rarely brown, in colour;

* These chlorite fibres differ somewhat in aspect from those other chlorite fibres which so largely make up the mass of the indurated rocks of which I shall speak later on. These latter, where occurring singly, often strongly recall prochlorite in its vermicular shape, as seen in quartz from the less altered contact schists of Beechworth.

and these colours are somewhat lighter than is usual in the hornblende of the district. In those slices which are parallel to the most perfect cleavage there are only faint traces of cross cleavage; in those perpendicular to this direction the cleavage in one direction is well marked; less well marked are irregular directions crossing it. More rarely I have met with sections which showed a very imperfect prismatic cleavage, approximately near to 124° 30′. The angles of inclination of the principal optical section against the direction of the most marked cleavage (*i.e.*, against the direction of the axis c), are higher than is usual in hornblende. My measurements gave me, for those sections showing a well-marked cleavage, 12°—22°, and in one instance 26°. The sections of this mineral are moderately, and even occasionally strongly, dichroic, in spite of the rather light tints of the mineral.

These observations indicate a monoclinic mineral, occurring in irregularly bounded crystals, having a perfect cleavage parallel to $\bar{\text{ii}}$, with a metalloid and vitreous lustre, a less perfect cleavage parallel to I, and an imperfect cleavage parallel to ii. Its monoclinic optical characters, its polychroism, and its prismatic cleavage near 124° 30′, refer it to amphibole, while its physical character and its marked cleavage in the direction $\bar{\text{ii}}$ point to anthophyllite. I therefore refer it to that mineral sub-species which Des Cloizeaux has termed amphibole-anthophyllite. I have observed an interesting parallel between this mineral and the pyroxenic mineral diallage. It may be said that this amphibole-anthophyllite stands in the same relation to amphibole that diallage does to augite.* The inclusions in this mineral are peculiar. They may be regarded as constituents of the rock of which amphibole-anthophyllite forms almost the whole; but it will be most convenient to deal with them in this place.

Orthorhombic Pyroxene—A mineral which I refer to this group is in imperfect crystals, or in masses of crystalline granules. It is found between the cleavable masses of amphibole rather than in them, and conforms to their outlines. Macroscopically, I have observed it to be of a rather light clear brown colour, having a resinous lustre and a marked cleavage,

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* Anthophyllite is to amphibole as enstatite is to augite. Rosenbusch *Mikroskopische Physiographie der Massigen Gesteine*, p. 263.

the lustre of which is somewhat vitreous. It becomes transparent in the thin slice, and is then either colourless or faintly reddish. It is remarkably fresh and unaltered, and is free from inclusions. Most usually the sections show a longitudinal somewhat perfect cleavage; occasionally a slightly undulating, finely fibrous structure; rarely (and this seems to be in sections across the former) a prismatic cleavage of nearly 90° and two pinacoidal cleavages, of which one is more perfect and the other less perfect than the former. The plane of vibration in the longitudinal sections is parallel to the cleavage, and in the cross sections diagonal to the prismatic cleavage. Absorption is not marked, but the mineral is still polychoic. In the longitudinal sections the dichroism is in light shades of red to colourless; in the sections across the prism in light shades of red and pale orange red. These observations indicate an orthorhombic mineral, having a perfect cleavage according to one pinacoid, a less perfect prismatic cleavage of nearly 90°, and a least perfect cleavage according to the other pinacoid. Assuming the most perfect cleavage as parallel to $\breve{i}\breve{i}$, the axis colours would then be as follows:—$\breve{a}$, pale red; $\bar{b}$, pale orange red; $\overset{|}{c}$, grey or colourless. The mineral is not affected by boiling with hydrochloric acid. These observations agree exactly with the characters of hypersthene as given by Rosenbusch and Des Cloizeaux; but I have not observed the microscopic plates which are generally regarded as characteristic of it. The optical characters of this mineral place it in the enstatite-hypersthene group; and the question arises—"Have we a dichroic enstatite, or a hypersthene without the microstructure of that mineral as found at Isle St. Paul? I should decidedly reply in the affirmative to the second part of the question, for the pleochroism cannot be due to inclusions, but may result from the composition of the mineral."* I may note here that the only other mineral which might be indicated by the orthorhombic character of this species would be andalusite. But the red ray in this case is $\overset{|}{c}$, so that thin slices perpendicular to the prism remain colourless when tested by the polariser alone. A second constant inclusion in the amphibole-anthophyllite is *olivine*. It is found invariably as rounded or elliptical grains. In the thin slice seen by ordinary light they are colourless, free from inclusions excepting

*Rosenbusch, *Op. Cit.*, p. 479.

rarely magnetite, and have a somewhat rough-looking surface. A net-work of cracks traverses them, which are filled by magnetite. Similar irregular cracks radiate from these inclusions and connect one with the other. This mineral polarises in bright shades of red and green, and has some general resemblance to quartz in its chromatic effects. Not one instance afforded me any outline from which the crystallographic system could be deduced. The general appearance, structure, and chromatic polarisation suggested olivine, and this is confirmed by the mineral being readily attacked in the slice by hydrochloric acid. After a little time, when thus tested, particularly if heat is applied, these inclusions become opaque, and remain dark when rotated between crossed nicols. The whole of the magnetite is also removed from the network of cracks. It is remarkable, however, that few, if any, traces of serpentinisation are apparent. These inclusions of olivine somewhat resemble similar ones which I have observed in a sample of gabbro from Volpersdorf. A third inclusion belongs to the *spinel* group. Scattered irregularly throughout the whole mass, but I think almost wholly in the amphibole, are many grains and masses of grains of irregular outlines, and when of sufficient tenuity having a rich green colour. Very rarely I have observed instances where these grains were rectangular—*i.e.*, in sections of the regular octahedron. When examined in a thin slice ready for mounting by reflected light, these grains are seen to stand above the surrounding mass and to be black and lustrous. As tested by a needle-point, I estimate their hardness as over 7. They are wholly unaffected by hot hydrochloric acid. By transmitted light the grains are, where sufficiently thin, translucent and of a rich green colour. Between crossed nicols, and also examined by the stauroscope, they prove to be isotropic. These physical and optical characters point to one of the spinel group, either picotite or pleonaste. *Pyrite* occurs sparingly throughout this rock in grains. It is macroscopically visible, and in the thin slices may be identified with those opaque black masses which remain after the *magnetite* has been removed by hydrochloric acid.

The alterations which have taken place in this amphibole-anthophyllite commence by the production of a fibrous structure parallel to the axis c. This destroys the glassy aspect of the perfect mineral, but does not alter its monoclinic optical character. I have observed round the edges

of the plates and perpendicular to them a more or less wide margin of colourless overlapping fibres. Some alterations have produced aggregates of colourless scales which have a strong resemblance to talcose pseudo-morphs after hornblende,* such as I have observed elsewhere. Connected with these alterations and throughout the altered spaces patches of iron ore (magnetite) have been deposited either irregularly or between the fibres, and similar deposits have been made in irregular branching cracks which traverse the whole mass. The alterations, as might be expected in such essentially magnesian minerals, are rather serpentinous and talcose than chloritic.

Here and there throughout the mass I have observed what seem to be alterations of some original mineral constituent. They are very finely fibrous, the fibres being strictly parallel to each other. They are faintly yellow and dichroic. Optically the plane of vibration accords with the direction of the fibres. Unless these are allied to chrysotile I am unable to suggest their nature.

Pyroxene.—This mineral species is very rare, and I have only found it in the massive very hornblendic diorites of the Gum Forest; very rarely in the coarse grained granitic diorites of the lower parts of Riley's Creek, and in the amphibolite dykes. It is invariably almost colourless in the thin slices or only faintly yellow or brownish yellow. It has the character and cleavage of augite. The angles of obscuration in the slices I find to be 30° to 44°; none of the slices are sensibly dichroic. It occurred, without one exception, in more or less imperfect crystals having the form of augite.

The alteration of this pyroxene has produced an almost colourless chlorite otherwise similar in character to that I have found elsewhere derived from hornblende. It is rather broadly fibrous, wavy, and but faintly dichroic. Iron has been separated either from it or from the associated hornblende, and deposited either between the chlorite fibres or in separate masses either as magnetite or as ferric oxide, in which case it is often bright red and translucent. I have also observed under favourable circumstances that the chlorite is often formed of minute, thorn-like fibres, which are either arranged approximately parallel or else as slightly

* These apparently talcose alterations are not affected by hydrochloric acid.

divergent tufts. Such needles often border the edges of hornblende.

Such a colourless pyroxene, having the form and optical properties of augite, would be diopside.

Mica.—Magnesia mica is the only one found in these rocks. It occurs as an essential constituent in the dioritic and granitic rocks at Riley's Creek, at Upper Swift's Creek, at Eureka, and generally in the fall from the various gaps at Upper Riley's Creek towards the Tambo. On examining the forty slices which I have selected as presenting an average of the whole, I find that it occurs with felspars of group 1 three times, with 1 and 2 twice, with 2 once, with 1, 3, and 4 thirteen times, with 2, 3, and 4 once. Magnesia mica, therefore, may be said to show a preference for the potash felspars, microcline, and orthoclase, and in a less degree for the soda felspar albite. In the one instance when it occurs in company with anorthite, it differs somewhat in its characters from those usually seen. Magnesia mica is most frequent in those rocks which lie on the outskirts of the intrusive mass, and more especially near the contact, when there is a distinctly gneissic structure.

It is not met with as crystals, but as masses or aggregates of bent, twisted, or divergent flakes. It occurs either as disseminated flakes, or as filling in between the various constituents, or enveloping the felspars; when associated with hornblende it is often intimately connected with it by intergrowth.

This mica is usually brown or reddish-brown by light transmitted in the direction of the chief axis, and when examined in a direction perpendicular to this by the polariser alone it is strongly dichroic, the dfference in the colours being pale straw-yellow to almost black. Almost all this mica is optically binaxal, but I have observed a few instances where the mica was, so far as I could observe, uniaxal, or binaxal with a very small angle; and in the slices where this mica occurred I could observe distinctly that one or two minute isolated flakes had hexagonal outlines. I have, however, only met with this in the close-grained micaceous portions of the massive quartz diorites of Riley's Creek, and in the crystalline granular compounds of felspar and mica which constitute the fine-grained parts of the massive quartz diorites of Eureka. Examined stauroscopically the flakes were either uniaxal,

or the angle was so small that the disturbance of the cross was barely perceptible.

One variety of the binaxal magnesia mica I have found to be peculiar to the anorthite diorites of the upper part of Riley's Creek and of the Sheep Station Creek Gap. It is red by transmitted light, and has a peculiar coppery sheen by reflected light. It is strongly dichroic in shades of yellow to dark red and almost black. It is decidedly binaxal. It occurs in slightly divergent groups between the felspars, and also intimately intergrown with hornblende. (Fig. 23.)

The inclusions which I have observed in the magnesia mica are almost wholly apatite and magnetite. The former is found to penetrate the various plates, and, in some instances, assuming the form of the mica to be rhombic, to be arranged parallel to the prismatic sides. Very rarely I have observed minute plagioclase prisms, amphibole particles, or portions of ground mass, but such occurrences are very exceptional.

These micas are extremely well preserved, and only rarely show signs of alteration or decomposition. The alterations produce a substance which I cannot distinguish from the chlorite resulting from the alteration of hornblende. In places the whole of the mass of mica plates has been altered, while elsewhere the changes have affected only individual plates.

Figs. 24, 25, are given to illustrate the above statements.

Titanite.—I have only rarely been able to identify this mineral, even after very careful and special examination of those examples in which it might be expected to be present. Most commonly it is in crystalline grains, associated with hornblende or magnesia mica.

Apatite is of very common, almost universal, occurrence in the diorites, and, I think, especially in those which are most granitic in character. I have not observed any special features to note.

Magnetite.—I have already referred frequently to magnetite, and I may now only add that much of that seen is probably of secondary origin, and due to alteration of amphibole, magnesia mica, and, in a less degree, of pyroxene.

Pyrite occurs here and there in the more basic diorites, and especially in the neighbourhood of the mineral veins. In the former cases it is most frequently found in granules, in the latter crystallised in modified forms of the cube.

In many cases, and especially in those quartz diorites in which magnesia mica is a constituent, I have observed, interpolated among the mica plates, mineral aggregates of a pale-yellow or brownish-yellow colour. They have a somewhat rough appearance of surface, and are sensibly dichroic. They show minute aggregate polarisation in bright shades—mostly greens and reds. It seems to me most probable that this mineral is an alteration product. I have found similar aggregates filling in spaces or adjoining the felspars, in one case surrounding hornblende. It has suggested itself to me that this may be epidote, or in some cases even epidosite.

Classification of the Igneous Rocks.

All these rocks are intrusive, and in nowise contemporaneous. The following classification may be made:—

Granites.—This group is confined to the eastern part of the intrusive area, as, for instance, the Long Gully and the Sheep Station Creek. Its members are all of a quartzose character. The predominant felspar is orthoclase, which is usually in crystalline masses, but is also met with crystallised. Potash felspar also occurs in its triclinic form microcline. Plagioclase is always more or less present in well-formed prismatic crystals. Magnesia mica is very constantly present, but is occasionally almost wholly replaced by hornblende, while elsewhere both are found together. Here, then, we have granitite as the prevailing rocks of this class, and also an amphibole granite with varieties connecting the two. Where a large amount of plagioclase is present, there is a passage to the adjoining quartz diorites.

Quartz Diorites.—Rocks of this class are found adjoining the granitites, as at Riley's Creek, or in the outer parts of the intrusive mass, as at Eureka and the upper part of Swift's Creek. Quartz is often a marked constituent, in which case the rock assumes either a strongly gneissic or granitic character. It is most usual, however, for the triclinic felspars to predominate; and out of twenty-four slices which I selected as representing this class (all of them containing quartz as an essential constituent) I found that one contained felspars of group 1; five of groups 1 and 2; two of group 2; one of groups 2, 3, and 4; and sixteen of groups 1, 3, and 4. I have to remark again that the most quartzose rocks are those which contain the potash and soda felspars; while those which contain the lime felspars are almost or wholly quartzless.

In addition to the quartz and felspars, hornblende and magnesia mica occur either singly or together. In the gneissic rocks of this class (plagioclase gneiss) of Riley's Creek, mica predominates almost entirely to the exclusion of hornblende. But when microcline represents the triclinic felspars, I find both. In addition, the accessory constituents are apatite, titanite, magnetite, and pyrite. These rocks are, therefore, *quartz diorite* and *quartz mica diorite;* and they are connected by those rocks which contain both hornblende and mica.

It must be noted that a rock composed of quartz, a potash felspar, and hornblende or mica, would be a granite; but as the distinctive feature of the quartz diorites is that their felspathic constituent is triclinic, I have considered those granitic rocks in which microcline is the felspar to be a peculiar form of quartz diorite, to which class they are in position more nearly allied than to the adjoining granites.

Diorites.—The true diorites—that is, rocks composed of a triclinic felspar and hornblende, or of those minerals together with mica—are found at Riley's Creek, Sheep Station Creek Gap, Upper Swift's Creek, and Eureka, and are all, so far as I can ascertain, subsequent in age to their more acid allies. The two constituents, plagioclase and hornblende or mica, vary much in their relative proportions; so that on the one hand there results a crystalline granular felspar rock with a little hornblende or mica, and on the other a crystalline or crystalline granular hornblende rock with a little triclinic felspar; but so far as I have observed, mica does not anywhere, like amphibole, preponderate to the exclusion of the other constituents.

It seems that when the felspar predominates it is principally anorthite with a little and very subordinate soda lime felspar (albite, or oligoclase), and the associated magnesia mica a phlogopite; when the hornblende predominates, the felspars are probably albite, oligoclase, labradorite, or anorthite, and in extreme cases are almost invariably only present as imperfect crystals or granules in the amphibole. These rocks would, therefore, be varieties of *diorites,* varying in character from a compound nearly approaching *amphibolite* to one which on account of its felspar being anorthite would be allied to *corsite.*

Amphibole-gabbro.—I have found adjoining those varieties of diorite in which hornblende predominates

most, an intrusive mass, seemingly latest in age of all, and which is almost wholly composed of a mineral which I have referred to amphibole-anthophyllite. I have already so fully described the characteristics of this rock-forming mineral, and also of the associated mineral species, that but little remains to be said excepting to indicate the position which it seems to me should be assigned to the rock itself in the petrographic system. It has many resemblances to gabbro, but the departure from gabbro is in the occurrence of an amphibole mineral instead of diallage. Many of the normal gabbros are characterised by a preponderance of a monoclinic pyroxene, having a pinacoidal cleavage, associated with an accessory orthorhombic pyroxene. This abnormal gabbro has preponderating monoclinic amphibole having a pinacoidal cleavage, and has an accessory or orthorhombic pyroxene. For such a compound a special name is still wanting, and the most appropriate, although cumbrous, one would be amphibole-gabbro.* Such a rock stands to diorite much as the normal gabbro does to diabase and melaphyre.

(d.) Dykes.

In speaking of the dykes of the district, I have found it most convenient to depart somewhat from the general plan of this essay, and to describe each of the classes from typical instances rather than to enter first upon a description of the component minerals.

The dykes of the district include the classes felsite, diorite, and diabase. The former are met with in the eastern part traversing the metamorphic schists, and their age is quite uncertain. A few also occur throughout the western part of the area described. They are often granular and quartzose, and are then often much decomposed, and generally have a resemblance to the dykes of granular felsite common in the neighbourhood of Omeo. Elsewhere, as at Sheep Station Creek and the lower part of Riley's Creek, they are compact, hard, grey or bluish in colour, and seem externally but little affected by the agencies which have decomposed the adjoining granites or diorites. The diorite dykes are met with most commonly in the tracts surrounding the intrusive area, but also traverse parts of it, as, for instance, the quartz diorites

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* Streng has described a hornblende-gabbro from Duluth, U.S.A. See *Neues Jahrbuch*, 1877, p. 113.

and gneissic diorites at Lower Riley's Creek, and on the hills between that place and Long Gully and the hills near Eureka. Diabase is rare, and so far seems only to occur at the lower part of Swift's Creek in the altered schists.

Compact Felsites.—Dykes of this class occur only, so far as I have observed, at the source of the Sheep Station Creek, and not far from the intrusive masses of anorthite diorites. They traverse the granitic rocks at that place in directions approximately north-west and south-east, the dip, if any, being probably to the south-west at a high angle.

Slices were prepared from four large parallel dykes, occurring within a distance of about twenty chains, and from six to twenty feet in width. The appearance of the dyke-stone was in each case felsitic compact, of a greyish or bluish grey tint, and seemingly much less affected by atmospheric influences than the enclosing granitic rocks.*

Three of these dykes as examined in thin slices formed a series differing only in the relative minuteness of the mineral components. In one the structure is so minute as to be almost crypto-crystalline. In it, however, faint traces of minute felspar prisms are visible, with some few porphyritic crystals of the same. Here and there are small patches of a dichroic viridite, but the amount is small.

The second sample has a crypto-crystalline, grey coloured ground mass, in which are many minute plagioclase prisms, and fibres and patches of viridite. In this are elongated larger prisms, having the form usual in plagioclase, as also some iron ore (probably magnetite).

The third example has a micro-crystalline ground mass, composed, apparently, of felsitic particles, a little quartz and viridite, both diffused in fine particles, and as flakes and fibres. In this ground mass are—(1) Rather long and narrow interlacing or approximately parallel prisms, having the habit of plagioclase, (2) minute aggregate of some micaceous mineral, (3) magnetite, (4) quartz grains filling in spaces, (5) much viridite in patches.

In all these examples the felspar has been completely altered to minute aggregates of some micaceous mineral; no striations remain anywhere visible. Their form, however, is exactly that of plagioclase. The rock itself has evidently been much altered. The viridite (chlorite ?) may be referred

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* These granitic rocks are intermediate in composition between amphibole granite and quartz diorite.

to the alteration of amphibole. The general character of the rock, the proximity of the dykes to the intrusive anorthite diorites, their non-occurrence elsewhere, point to their being a plagioclase felsite.

The fourth dyke examined is of a very finely granular, approximating to a compact, texture. It has a crypto-crystalline ground mass of minute, doubly-refracting particles, in which are—(1) Minute plagioclase prisms; (2) iron ores (magnetite and pyrite ?), and (3) a large amount of viridite (chlorite ?). This rock evidently approaches in composition those diorites of the immediate neighbourhood in which the amphibole (here converted into viridite) preponderates over the anorthite or labradorite felspars. This dyke might be classed with diorite (aphanite).

Diorites.—Dykes of this class are of very frequent occurrence near the contacts, but are also found throughout the whole intrusive area, with the exception of the tracts of anorthite diorite and amphibole-gabbro, which they do not penetrate. These dykes are from a foot to 5 feet in width, and have not any common direction of strike. They vary much in texture, from finely crystalline or almost compact to a texture in which the crystalline individuals of white plagioclase and dark-green hornblende are clearly distinguishable by the naked eye. In extreme cases the individuals may be even ·25 inch in diameter. I have observed only one instance which could be described as a porphyritic diorite. This occurs traversing the gneissic quartz diorite near the contact at Swift's Creek.

I have prepared and examined slices of various of these dykes, which I now note.

Dense diorite.—Many dykes of this class occur throughout the district. An example taken from one penetrating the schists on the eastern side of the intrusive mass gave me the following:—The rock is micro-crystalline, having a crypto-crystalline ground mass in which are many minute plagioclase prisms, a little iron ore, and a large amount of viridite, to which the green colour of the rock is due.

Another dyke of this character which penetrates the amphibole granite near the eastern boundary, showed me, when examined as a thin slice, that it consisted of a crypto-crystalline ground mass, having traces of what may have been a glass basis. In this are many long and narrow prisms of plagioclase. A large amount of light-coloured viridite, in flakes and twisted fibres, is distributed throughout

the whole mass. Quartz is rather plentiful in small clear grains, which, however, often suggest that they are secondary. Throughout these and throughout the whole mass are very many minute apatite needles. Ores of iron have been deposited besides those magnetite crystals, which may be regarded as original.

Crystalline Granular Diorites.—The dykes of this variety are found occasionally throughout the district, and are usually strong and persistent. One of them traverses the schists on the eastern boundary. As usual, the thin slice showed me that the rock has undergone much alteration. The main mass is made up of more or less imperfectly formed, but rather stout, prisms of triclinic felspars, all of which, with few exceptions, are completely altered into aggregates of some minute micaceous mineral. In none of those which still showed striations could I obtain measurements. Between these felspars there have been small, elongated prisms of hornblende, all now converted into strongly dichroic chlorite. Whatever little ground mass there was has become involved in the general micaceous and chloritic alterations. A little quartz fills in spaces.

Another and somewhat similar dyke traverses the edge of the metamorphic schists in the same neighbourhood. It runs for two or three miles, and varies in texture. I prepared samples taken from the most crystalline granular part of this dyke, showing the apparently least altered rock, and also examples from a little distance, where the alteration seems to me to be at a maximum. I found a thin slice of the former to be composed as follows:—(1.) Felspars numerous, and in well-defined prismatic crystals, both singly and doubly compounded. The angles of obscuration measured gave me from 15° to 23° 30′ on either side of the composition face, and this would, I think, point to labradorite. The felspars are all more or less converted into aggregates of some minute micaceous mineral (soda or lime mica ?). The inclusions are apatite and, rarely, small flakes of hornblende. (2.) Hornblende, in flakes or imperfectly formed crystals, showing the prismatic cleavage of 124° 30′. They are frequently twinned, and are strongly dichroic. They include portions of ground mass and magnetite. The hornblende has been in places converted into chlorite, with the production of iron ores. In another slice the hornblende was replaced by brown dichroic magnesia mica. Quartz fills

in spaces between the other minerals. The sample taken from the most altered part of the dyke had a very hard, compact texture, and a reddish colour. I found it extremely difficult to prepare, in consequence of its great hardness and toughness. The slice showed me that it is a confused mass of flaky and fibrous aggregates. Some are radiating, some only divergent. Ores of iron have been extensively deposited between the flakes and fibres, most frequently amorphous, but also in octahedral crystals, and here and there in the mass are quartz grains. When it is possible to examine the fibres optically I found them to become obscured where the longer diameters are parallel with the plane of polarisation of one of the crossed nicols. The appearances seen in this rock resemble serpentinous alterations; but they are not pseudo-morphous. It appears to be a case of complete molecular re-arrangement of the rock with, perhaps, abstraction of some of the constituents. This dyke, in its original state, was evidently a crystalline granular hornblende and mica diorite.

Porphyritic diorite only occurs in one place, as I have before stated. A slice of the dyke showed me a crystalline granular ground mass, in which are many small, dark-coloured, not very dichroic flakes of hornblende. There are also minute aggregates, which I suspect to be felspar granules. Viridite is either disseminated, or occurs in patches, having a somewhat radial structure. In this ground mass are large dark-brown glassy porphyritic crystals of hornblende.

The slices of this hornblende are not very dichroic, are much fractured, and occasionally twinned. There is but little iron ore. The hornblende is very fresh and unaltered. It occurs in the form of I, ii, o. Besides these porphyritic hornblendes there are also porphyritic patches of alteration products, perhaps representing felspars, which are otherwise not present.

Amphibolites.—Dykes of this class occur principally at Riley's Creek, and bear much resemblance to the crystalline granular diorites, in which the amphibole preponderates to the almost exclusion of the triclinic felspars. A sample from such a dyke at the lower part of Riley's Creek, near the contact, is coarsely crystalline, and inclining to olive-green in colour. A thin slice showed me that the principal constituent is amphibole in not very perfect prisms, cross sections of which show the characteristic cleavage. It becomes translucent in shades of green or yellowish-green, and the

sections are moderately dichroic. It is not fibrous, but yet not glassy, as are many of the hornblendes of the diorites. It takes up most of the space in the slice. Next to it in a mount is a colourless and not dichroic pyroxene, either separately or grouped, of several more or less perfectly prismatic crystals. The characteristic twinning of augite occurs. This being an augite-like pyroxene, with very little iron, is probably diopside. The angles of maximum obscuration of the amphibole and pyroxene I found to be as high as 16° 39′ in the former and 44° in the latter. The most interesting feature in this rock is, however, the constant intergrowth of amphibole and pyroxene. In Fig. 20 I give an example.

In another instance in the same slice the pyroxene formed the nucleus of the amphibole crystal. The alterations which I observe in this slice have been principally the production of an almost colourless chlorite, otherwise precisely similar in character to that I have described when speaking of the diorites as the result of alteration of the hornblende. It is rather broadly fibrous, undulating, and only faintly dichroic in shades of green. Iron ores have separated, and are deposited in the chlorite or in masses, either as magnetite or ferric oxide, and in the latter case it is in red and translucent flakes. I have also observed the incipient formation of chlorite as minute acicular fibres fringing the margins of the amphibole.

No felspars are recognisable; but if any existed they may be now represented by some small spaces filled by minutely-constituted, brightly-polarising aggregates. No quartz is met with in the slices.

In another sample obtained from a dyke in the neighbourhood of the last, I found the amphibole to be in prisms much drawn out in the direction of the chief axis, and prismatic cleavage well marked in the cross-sections. The angles of obscuration in these amphiboles are large, being, according to my measurements, as high as 21° 30′. Many of the smaller crystals are twinned according to the ordinary law. These crystals form at least two-thirds of the rock, the remainder consisting of alteration products, among which is the usual chlorite, and also the minute aggregates spoken of in the last. In this slice, however, there are also a number of long and narrow plagioclase prisms in all stages of alteration, and connecting the scarcely altered individuals with the resulting minute aggregates before spoken of. In the only

instance in which I could obtain measurements of the angles of obscuration in the felspars I found them to be 5° on each side of the composition face.

A slice prepared from a third dyke in the same neighbourhood afforded me similar observations, with this exception, that in this case the colourless pyroxene amounted to perhaps one-third of the constituent minerals, and also constituted the nucleus of two crystals, thus showing that the simultaneous occurrence of amphibole and pyroxene is a case of envelopment and not of alteration.

Diabase.—The only dyke of this class which I have met with is found in the schists at a road cutting at lower Swift's Creek. A slice of this dyke I found to have a light-brown, cloudy, crypto-crystalline ground mass, in which are —(1.) Minute prisms of plagioclase, all of which are more or less converted into micaceous aggregates. (2.) Large porphyritic plagioclase prisms, in which the alteration is distinctly micaceous. Viridite has been deposited in these felspars. The micaceous alterations are mostly central, but also in some cases extend to the exterior. The angle of the principal optical sections in the sections of the crystals are from 15° to about 30°, thus pointing to labradorite. If this is so, the alterations must produce, as a colourless micaceous mineral resembling muscovite in its microscopic optical characters, a mica containing soda or lime. In other words, it suggests paragonite or margarite. Augite exists in yellowish crystals, which have, however, been mostly converted into chlorite. (4.) Magnetite, and also amorphous iron ores, probably the result of the alterations in the rock. (5.) Cavities filled by colourless carbonates, edged by delessite. This rock is evidently a porphyritic diabase, or, in accordance with the classification of Professor Rosenbusch, a diabase porphyrite.

(e.) The Contact Metamorphic Rocks.

Their Component Minerals.

Felspars.—In the contact schists, with the exception of one narrow zone of limited extent, the felspars are of extreme rarity. The triclinic soda and soda-lime felspars are in the minority, and the lime felspar anorthite is entirely absent.

I have found the soda and soda-lime felspars also as constituents of the aplite beds. These immediately adjoin

the intrusive masses near Odell's Creek, going north and east round to near Sandy Gully Gap. Here, however, the plagioclase is of such extreme rarity that its presence but proves the general rule as to its absence. Where it occurs it is in well-formed, prismatic crystals, resembling those of the granites. I was not able to obtain any measurements. Felspars occur in the hornfels zone so rarely that it may be stated as the rule that they are not found there at all. The only instances I met with were in the actual contacts of the hornfels and quartz diorite. From the best example which I collected, which was taken from the adit of the Black Prince Mine, at Eureka, I was enabled to prepare a slice across the contact of the two rocks, the hornfels being in this case a very quartzose example. A number of granules and some perfectly-formed crystals of felspar are situated among the granules of quartz near the contact line. The position of these felspars, only when close to the dioritic rock, and their mostly sharp and well-marked outlines, proved that they are secondary, and not original, constituents of the sedimentary rock. The largest felspar crystal is composite as to one half and simple as to the other, the lower part of both halves being very homogeneous, except where crossed by a few laminæ. The angle of obscuration is not the same in the upper and the lower parts, being in the former 14° and in the latter only 11°. From the structure and optical characters, I think this felspar belongs to group 1 (albite or oligoclase). Besides the large crystal, there are other triclinic felspars in mere granules, in which no measurements could be obtained.

In the aplite bands which lie nearest to the intrusive masses there is, beside the small constituent amount of triclinic soda and soda lime felspars, which I have already mentioned, a very large amount of triclinic and a lesser amount of monoclinic potash felspars.

The triclinic potash felspar is crystalline granular, and nowhere well crystallised. It has shades of pale flesh red to white. In order to test the presumption raised by my first examination of some thin slices of these rocks, I broke up an average piece of the rock, and by aid of the lens selected a number of the minute flakes which had been separated from the most perfect cleavage. Some of these I examined qualitatively before the blowpipe, and others I prepared as microscopic objects; the former gave (BB) a slight sodium and a strong potassium flame reaction, and tested in the wet

way gave a strong precipitate of chloride of platinum and potassium. Those fragments which I examined under the microscope by polarised light, and between crossed nicols, all showed more or less perfectly the peculiar twinned and cross-barred structure characteristic of microcline.

An examination of thin slices of this rock taken from near sketch section No. 1, sketch section No. 2, and sketch section No. 3, showed me that in each case the same peculairly twinned triclinic potash felspar formed the greater part of the crystalline granular mass. In Figs. 16, 17, 18, 19, I give some characteristic instances.

The orthoclase in this rock does not offer any marked peculiarities. It is quite subordinate, except locally.

In accordance with the plan upon which I have constructed this essay, there ought to follow here an enumeration and description of the other constituent minerals of these contact schists, On attempting this description, I have found, however, that it is better to sacrifice mere method to the greater convenience of describing the constituent minerals when speaking of the contact schists themselves, and to do this partly from slices of typical rocks, and partly from such slices in connection with the detailed descriptions of the sketch sections Nos. 1, 2, and 3, which will follow in the next few pages. All that is necessary, therefore, will be to mention now that the mica of the aplite beds is a colourless or slightly greenish silvery mica, having all the microscopic optical characters of muscovite. In typical aplite rocks it is extremely rare, but in other samples it increases so much in amount that the rock becomes a form of muscovite granite. In the latter case magnesia mica is frequently associated with it.

Quartz also occurs in the aplite rocks as an essential constituent. It occasionally contains fluid cavities with movable bubbles. Inclusions in the felspar or quartz of the aplite are extremely rare and undefinable.

It only remains before proceeding to speak of the contact schists, to refer to the small limited zone in which is found the felspathic rocks I have just mentioned.

The contact schists fall naturally into zones, of which the most highly altered immediately adjoins the igneous mass. In the immediate contact of the igneous and sedimentary rocks there are beds of a more or less well marked crystalline granular felspathic character; on one side they all join, and even are partly included in the igneous masses, and on the

other alternate for a short distance with other contact sediments. They are composed mainly of crystalline grains of felspar and quartz, and have often, as an accessary constituent, a silvery or greenish muscovite mica. This last is locally so abundant that a muscovite granite results. The felspars are mostly triclinic. The quartz fills in interspaces as granules, but other spaces are filled by small crystalline grains of felspar. Such a rock resembles in some respects a granulite of the regional metamorphic series, but it differs in having a more granitic character, in having potash mica, and in wanting the constituents schorl or garnet which are characteristic of the granulites of the neighbouring regional schists. The most appropriate term for such rocks is *aplite*—a semi-granite. They may be regarded as being in the contact series the analogues of the granulites of the regional series of metamorphic schists.

Athough in hand specimens these rocks could scarcely be suspected to be altered sediments, yet the examination of them in the field left no doubt in my mind as to their original character, nor that their present condition is due to the complete molecular re-arrangement and metamorphism of the sediments.

I now come to speak of the next lying zone—hornfels. These rocks fall naturally into two groups, the quartzose and the quartz free, representing the sandstones and slates of their former condition. The paste which more or less cemented the quartz grains of the former probably resembled the main mass of the latter. The quartzless samples of hornfels which I examined I find to consist of a groundmass, and also of what may be called pseudo-nodules. The alterations are all micaceous. The groundmass consists of minute flakes of some colourless micaceous mineral which either forms aggregates of crumpled folia or else which are to a certain extent parallel, and then simulate a homogeneous crystal by becoming dark simultaneously when rotated between crossed nicols. The pseudo-nodules often approach the true nodules in character by having narrow margins of mica plates separating them in part from the remainder of the mass. I have usually found that there was a considerable amount of black amorphous substance in flakes in these spots, and this appears to be a form of carbon surrounding these pseudo-nodules. The ground mass consists of two kind of material; first, micaceous aggregates, or else small overlapping plates of mica, with larger plates interspersed in the

mass. This mica is colourless, and reacts like muscovite. No hornfel that I have examined is without more or less magnesia mica as brown dichroic plates, which, however, are usually confined to the ground mass. I have not anywhere observed the interlacing thorn-like microliths which are so plentiful in the true nodular schists near at hand, excepting in one instance at the lower part of Sheep Station Creek, where I observed a few. Other microliths are probably minute mica plates, apatite needles, and colourless, imperfect crystals, whose nature I am unable to determine. In one example of hornfels taken from the immediate contact at that place where the amphibole granites have truncated the strata, I also observed very many minute black, dark green, or dark brown microliths, having brush-like terminations at one or both ends. These occurred generally in such manner that two or three crossed each other, thus forming a radiating group. On a very small scale, but much darker in colour, they bear much resemblance to bladed and also radiating amphibole (actinolite ?), which I have observed in a compact diorite near Bright. Perhaps these may be referred to the same class.* In another sample of schistose hornfels taken from near the same place, I observed spaces which were perfectly clear and colourless by ordinary light, but which, by polarised light, seemed at first sight to be mainly isotropic. On, however, using a higher magnifying power I found these spaces to break up into slightly discordant plates, which were certainly, although slightly, doubly refracting. The quartzose hornfel is composed, more or less, of irregular granules of quartz of the character of those of the normal sandstones. I observed no fragments of the felspars intermixed with them. The quartz granules composing this kind of hornfels are set in what was once a more or less plentiful paste, which, in the least-altered examples, resembles that which I have observed similarly placed in the Silurian quartzose sandstones of the district. The changes which have taken place in this paste are analogous to those I have

* See as to these microliths Zirkel *Mikroskopische Beschaffenheit der Mineralien*, 1870, p. 491. In an example of nodular schist from Swift's Creek I have also found numbers of these acicular microliths; examined with a power of 350 linear, I found the larger ones to be yellowish brown in colour, and distinctly dichroic. The minute size, ·0015 x ·0003 inch, rendered it impossible to observe whether the plane of vibration coincided or not with the direction of the sides. The smaller individuals still appeared merely as black lines.

noted in the quartzless hornfels. The interspaces are occupied by aggregates of minute plates of some colourless mica, which reacts, like muscovite, where larger plates occur, and can thus be tested. Besides these there is always a considerable amount of brown dichroic magnesia mica interposed between and around the quartz granules; and the individual size of the magnesia mica is, as a rule, more considerable than that of the muscovite. The most remarkable alteration products are vast numbers of microscopic, round, oval, rectangular, and irregularly shaped plates, which cling to the surface of the quartz grains, and even seem often to be implanted therein. I have observed more than once where a swarm was situated apparently near the centre of the quartz grain, that I could cause a succession to appear by altering the focus of the object glass, without, excepting occasionally, being enabled thereby to detect any capillary flaw connecting them.

The alterations, therefore, which I observe in the contact schists are, outside of the aplite zone, wholly micaceous. In the conversion of the aluminous portions of the sediments into mica, the silica which would be set free seems partly to have been deposited surrounding the original quartz grains, and partly to have formed aggregates of crystalline grains in the less highly altered varieties. In the true hornfels, which may be regarded as one of the former quartzless sediments, the silica seems to pervade the whole mass, and probably helps to give the rock its peculiarly hard and, with the mica, its tough character. Whether the magnesia mica derives its magnesium from the sediments or from solutions, percolating the strata during their metamorphosis, I am not able, in the absence of comparative analyses, to conjecture, and must leave undetermined.

The hornfels group, besides consisting of quartzose and quartzless varieties, also includes compact and schistose members—the former close-grained, heavy, dark grey, nearly black or bluish black in colour; the latter having much resemblance to the structure of a fine-grained gneiss, with this exception, that the alternating folia are mainly quartz and mica. This latter variety is often extraordinarily contorted.

The changes which I have sketched become gradually less and less marked as the distance from the contact increases, until at from twenty to sixty chains the rock masses have only the character of those indurated sediments which I have already described.*

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* See *ante*, p. 20.

(3.) The Interrelations of the Rock Masses.

The Igneous Rocks.

In passing across the more or less well defined contact boundary between the sedimentary and igneous rocks of Swift's Creek to the area of the latter, I have usually remarked these to consist of rather coarse crystalline granular compounds of quartz, felspar, mica, and hornblende, in which a gneissic structure is always more or less marked. These peculiarities of structure extend for various distances, and their extent depends probably not only upon local differences of crystallisation and cooling, which may well be supposed not to have been everywhere the same, but also evidently in many places on the irregularity of the contact plane, in respect to which the present surface rocks would have been situated at greater or less distances. Those rocks first met with are varieties of plagioclase gneiss, or more properly gneissose quartz diorite. In proceeding still farther beyond the contact towards the central masses, an increasing change is found. The granitic rocks become darker in colour by the increased amount of magnesia mica; and, at the same time, they are harder and tougher. The gneissic structure passes into an irregular crystalline granular structure. The texture varies much from a fine-grained rock, composed mainly of minute scales of black mica and quartz, to a coarse compound of quartz, felspar and a little magnesia mica, or blackish green to black hornblende. Other varieties intermediate between these occur, either singly or else even irregularly massed in the rocks themselves. In proceeding southward the rocks become more dioritic in character, and parts are met with along the southern boundary of the intrusive masses where hornblende so preponderates as to produce rocks such as the amphibolites. These rocks extend along the contact from Eureka to Riley's Creek, and it is here that the peculiar amphibole-anthophyllite rocks are met with. Still further round the contact, and at the Sheep Station Creek Gap, are the anorthite diorites. The contact phenomena of these rocks and the sediments do not differ from those found where the intrusive rock is of a more granitic character.

Thus, the area of the Gum Forest and of the upper part of Swift's Creek is occupied almost exclusively by intrusive rocks of the classes quartz diorite, diorite, and amphi-

bolite, in which the hornblende is often replaced by magnesia mica, when the quartz diorite in this their extreme form becomes, so far as physical character is concerned, true plagioclase granites. In leaving the Gum Forest and ascending toward the Tambo River, either by the Long Gully or the Sheep Station Creek,* a large tract is found to be entirely occupied by granitic rocks. We have here the usual physical character of country seen in granite areas—namely, rounded hills, but occasionally varied by summits crowned by rocks, or slopes dotted by weathered masses and tors of granite. The rock itself is usually a granitite or an amphibole granite, with varieties connecting both. Such granite rocks as these are found extending to the eastern contacts, where they are seen to have been intruded into the regional metamorphic schists and the less metamorphosed Silurian sediments of the district. The phenomena of contact in the granites are everywhere such as these I have described—namely, a strongly marked gneissic structure of the intrusive rocks near the contact, and perhaps an increase of potash felspar in them, due, I suspect, to the admixture of portions of the sediments which have been absorbed.

It soon becomes evident, in tracing out the contacts of the two groups of rocks at Swift's Creek, that the igneous masses are intrusive into and, therefore, younger than the sediments. The actual contact is, however, not always easy to point out, for the gneissose margin of the former and the greatly metamorphosed beds of the latter often interlock. But I have found, upon repeated examination, that those beds, such as aplite and hornfels, which alternate with the intrusive rocks, are, in fact, those extreme edges of the sediments which have remained attached to and in the consolidated igneous mass, while their extensions towards the sediments to which they belong have been denuded. I can also perceive that more than one irruption of igneous rocks has taken place, for I have observed that dykes nearly approaching the character of the amphibolites penetrate the granite and gneissic diorites. Similarly, I have observed that compact diorite dykes penetrate them, while the amphibolites, the amphibole-gabbros, and the anorthite diorites, so far

* The Sheep Station Creek falls into the Tambo River. The Sheep Station Gully is in the Gum Forest, and is the western branch of Riley's Creek. It is not lettered on the map.

as I know, contain no dykes. These dioritic and granitic rocks form a whole, as regards the sediments into which they have intruded, but in respect to each other, they are all also intrusive, and, I may say with some confidence, that the more hornblendic varieties are the latest in occurrence; so that we have the mental conception of a first invasion by quartz diorites and granites, followed by quartzless diorites, and these again by amphibolites, and bordered, except in the south, by a margin of quartzose plagioclase or orthoclase rocks whose gneissic structure is probably one of the phenomena due to contact with the sediments. Finally, we must also perceive that the metamorphism produced has been the result of all these intrusions, and, therefore, an intermittent process.

The Metamorphic Contact Rocks.

In describing the intrusive granites and diorites I passed from their contact with the sediments to them. I now reverse the process, and having briefly described the inter-relations of the intrusive masses, proceed to describe these altered sediments and their mutual relations, into which the former have intruded.

If we commence at the termination of the gneissic or granitic rocks into which the true quartz diorites appear to graduate near the contact, we shall find that the sedimentary rocks present to us certain appearances of alteration, which, broadly speaking, are applicable to the whole of the contacts surrounding the igneous masses. I may take an example from the lower part of Riley's Creek.

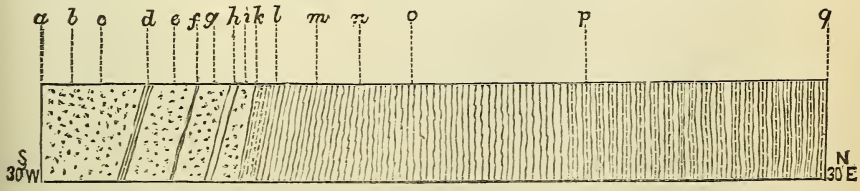

Diagram No. 1.—Section across Contact at Lower Riley's Creek.

Scale, about 40 chains to one inch.

a. Massive crystalline granular quartz diorites, with some magnesia mica.

b. Similar rocks, but with fine-grained portions, which are either in contorted foliations of short continuance, or in crystalline granular patches.

c. Similar to *b*, but the foliated portions more pronounced.

d. Massive, rather coarse, crystalline granular quartz diorites, as at *a*. In this is a band of indurated silicious hornfels. The beds are foliated, dipping south at 25°. They are traversed by irregular joints only a few inches apart, dipping north at 75° to 80°. The joints are silicified and very smooth. Silvery mica is deposited on some of the planes of foliation.

e. Massive quartz diorites, as at *a*, but having traces of a schistose structure.

f. Bands of hornfels, as at *d*, but only about 30 feet across in the whole.

g. Coarse grey quartz mica diorite, with a gneissic structure. This rock is composed of felspar (microcline, orthoclase, and a little plagioclase), magnesia mica, and quartz. The preponderance of triclinic felspars (including microcline) classes this as a diorite. Its structure is that of a gneiss.

h and *j*. There are here bands of schistose hornfels.

k. At this point the diorite-gneiss ceases, and there are thick bands of aplite. An example of the most felspathic variety showed me, when examined microscopically, that it is composed mainly of irregularly-shaped grains of felspar, the greater part of which is orthoclase, the remainder being microcline. Some grains are part monoclinic and part triclinic. There is no plagioclase and not much quartz filling spaces; nor is there any mica whatever.

l. The aplite gradually becomes less massive and more schistose, and alternates a little with schists.

m. Slaty or schistose sedimentary beds, the strike being east and west. These extend to *n*.

n. Finely-wrinkled micaceous schist, dipping south at 42°.

o. Bluish and greenish slates, only slightly micaceous.

p. Nodular argillaceous schist and micaceous quartz schist. This section crosses the strike of the beds.

I now give a second example from the Charlotte Spur, at a distance of about 120 chains westward from the last.

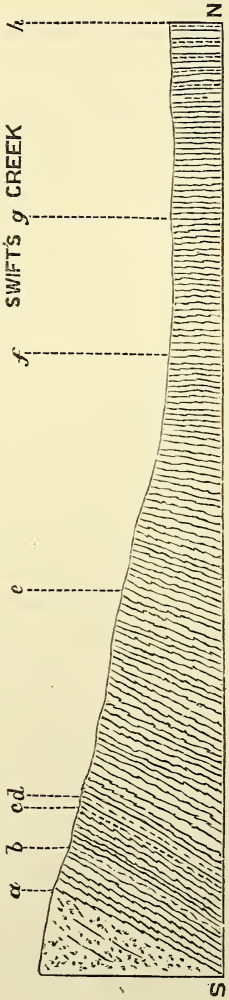

Diagram No. 2.—Section across Contact at Charlotte Spur, Swift's Creek.

Scale, about, horizontal 10 chains and vertical 700 feet to one inch.

The section is taken nearly north and south, and thus approximately lies at right angles with the strike of the beds.

a. The gneissic granite or diorite ends here, and a grey coloured, rather rough-textured schist commences, dipping south at 53°.

b. A band of granitic rock, much decomposed, conforming to the dip and strike of the schist, and about ten feet wide.

c. The grey schists end here. I prepared a thin slice from two samples which represented their average character from *a* to *c*.

The slices were prepared from schists, one of which was quartzose, and the other fine-grained and micaceous.

The former I found to be composed of grains and aggregates of grains of quartz, whose outlines are irregular. Between them are ragged-edged plates of brown and dull green mica. The paste cementing the quartz grains has been generally converted into an aggregate of minute scales of colourless mica, in which are far larger solitary plates, showing crystalline outlines, and also masses of slightly divergent plates of the same mica. I regard this as being muscovite. It is, however, the magnesia mica that reaches the largest dimensions, and it occasionally constitutes masses separating the quartz aggregates. There are only very faint traces of chlorite in some of the larger aggregates of muscovite mica. Black material occurs in ragged, opaque, and rather minute forms. It is not affected by hydrochloric acid, and is probably graphite. Other minute, black, or dark brown flakes are slightly translucent at their edges, and are therefore most likely a form of magnesia iron mica. The fine-grained sample showed me that which the general aspect of the schists in the field had suggested was the fact—namely, that they are mainly composed of mica, the quartz grains being few and small. In one sample, the quartz grains and the mica alternate with each other. The material which I have elsewhere spoken of as the "paste" has been wholly converted into mica, the ground mass being colourless, or pale green muscovite, with numerous flakes of brown magnesia mica scattered through it. There are scarcely any traces of chlorite. In this sample I observed the same opaque black substance in considerable amount, which I have spoken of as graphite.

d. Aplite in more or less irregular bands, conforming to

the dip and strike of the schists. The character of this aplite is that already described in the last section. The total thickness of these bands is about 120 feet.

e. A schistose rock, similar to that described at *c.* A thin slice prepared from a sample taken from this place showed it to be a fine-grained foliated rock. The ground mass is composed of minute plates of mica, which is either colourless or faintly brown. In this mass are small grains of quartz and flakes of brown magnesia mica. The plates of colourless mica which form the ground mass of this rock are, as compared to those of *c*, much smaller in dimensions, and consequently, the mass being the same, more numerous. As before, there is a considerable amount of amorphous, opaque, black material, and minute black or dark brown flakes. Microliths are of minute size and undeterminable character; some, however, suggest minute specks of chlorite.

f. The schists at this point have in the distance from *e* (about eleven chains) changed their character. They are no longer micaceous, and are less schistose and more indurated. Samples collected from this place I prepared as thin slices taken parallel to and across the planes of deposit, so far as they were ascertainable from the crumpled and contorted condition of the rock. The former show by ordinary light a colourless ground mass which, in the thinnest edges of the slice, suggests overlapping, minute plates. In this are vast numbers of minute bent and contorted, pale greenish fibres, which, when lying perpendicular to the slice, are seen as dots. These fibres are often arranged parallel to each other, or surround the grains and lenticular masses of quartz which lie in the ground mass. The dimensions of these fibres are too minute to afford satisfactory observations as to their being or not being dichroic; but so far as I could ascertain, they are. These observations suggest chlorite. The slice prepared perpendicular to the bedding showed the rock arranged in simulated foliations, the alternations being a ground mass, such as I have just described, in which the chlorite fibres are very numerous, and arranged in a direction parallel to the bedding, and a ground mass in which the chlorite fibres are very rare. Between and in these alternations are grains and lenticular masses of quartz. Throughout the mass there are minute black particles which are not affected by hydrochloric acid.

g. Here the rocks have assumed the appearance of indurated sediments, alternating somewhat in texture, and

dark bluish or greenish in colour. I prepared samples of both these rocks. A slice of the darker coloured rock (dull green) showed me that the ground mass is, as in *f*, colourless, and suggesting minute overlapping flakes. In this are vast numbers of minute chlorite fibres lying over each other in all directions. Traversing the mass are narrow and contorted veins of quartz; chlorite fibres extend from the ground mass into them, and their median line is marked by a chain-like row of such fibres linked, as it were, to each other. Besides these veins of quartz there are isolated grains and lenticular masses of grains of quartz. A slice of a somewhat more indurated and lighter-coloured sample from a bed adjoining the former showed a similar structure; but in this the chlorite is rather in flakes than in fibres, and is pale yellow or yellowish green in colour. In both varieties of rock there are occasional angular fragments of plagioclase round which the chlorite fibres have arranged themselves in a pseudo-flow structure.

As this point may be said to be the intermediate position between the contact and regional schists, the beds, in going northwards from this place across the strike, are increasingly altered. Nodules appear in one set of beds, while those alternating with them are indurated. The former are the nodular argillaceous schists, and the latter are the micaceous quartz schists before spoken of. At a distance of about ten chains from *g* these have completely assumed their distinctive characters as members of the regional metamorphic series of Omeo.

Following the contact beyond the last section, I obtained a third section across the contact, which I subjoin.

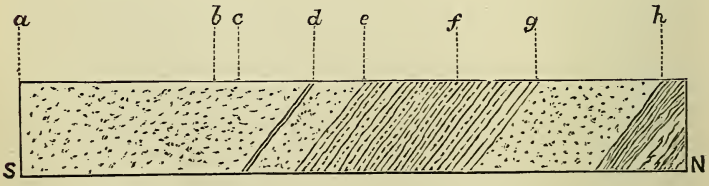

Diagram No. 3.—Section across Contact at Swift's Creek.

Scale, about 150 feet to one inch.

This is near the Old Fashion Reef, and about 55 chains to the south-east of section No. 2.

a. Grey felspathic quartz diorite.

b. Similar rock with more dark-coloured mica, and small, fine-grained, dark-coloured inclusions.

c. Similar rock with more mica.

d. The rock from *c* extends to here, where there is a band of aplite six inches wide dipping north-west at 60°.

e. Aplite beds, the bedding and jointing indistinct, but may be in accordance with that at *d*, and the jointing nearly perpendicular to that direction.

f. Some very irregular bands of schistose hornfels, say, six feet in width, traversed by many very minute joints.

g. Granitic diorite like that at *d*, but much decomposed.

h. Hornfels commence here. The rock is very hard and slightly spotted, but also in places schistose.

Beyond this, to the north across the strike, the schists gradually pass through the changes already noted.

In Odell's Creek still further round the contact towards Eureka, the contact of the igneous and sedimentary rocks is well displayed. The latter are much broken up, crumpled, and extensively altered. At some distance up the stream the sedimentary beds are seen to be cut across by the quartz diorites. The rocks resulting from these alterations and interferences are varieties of hornfels, from a close-grained, dark-coloured, crystalline rock almost resembling some varieties of basalt, to a schistose contorted rock resembling a fine-grained gneiss.

In places the contact is sharp, in other places the rocks interlock, and often the whole rock, igneous and sedimentary, assumes almost the same character. Many of the fine-grained inclusions in the granitic diorites along this contact strongly suggest that they are portions of sediments which have not been completely absorbed.

The instances which I have now given will sufficiently define and describe the group of contact schists, and are applicable *mutatis mutandis* to all parts of the contact surrounding the intrusive igneous masses. The diagrams show the series of contact schists to include indurated or silky slates, hornfels, and aplite, taking each of these to include varieties which connect the whole. They are clearly shown by their mode of occurrence, by the common direction of dip and strike, by the manner in which they alternate with and pass into each other, by varieties, and

finally by the increase of crystalline alteration in approaching the intrusive masses, to have had a common origin and to have been all affected by the same influences. It cannot, I think, be doubted that these influences were connected with the intrusive masses, and entirely to be distinguished from those other influences which produced the regional metamorphism which has affected the Silurian formations up to the very boundaries of the contact schists.

The course which these contact alterations have followed is, I think, indicated by the microscopic examination noted in the description of diagram, section No. 2.

The least-altered rocks which still clearly retain their sedimentary character are seen to be highly charged with chlorite, and to have been somewhat altered in structure by the aggregation of crystalline quartz in lenticular masses and narrow veins.* In passing across the strata towards the contact it is found that the chlorite decreases *pari passu* with an increase of mica, and thereby with an increasing crystallinity of the rock until the immediate contact schists (as at the Charlotte Spur) are found to consist mainly of mica, with only faint traces of chlorite, or, as in other places where the contact rock is a typical hornfels, the chlorite has entirely vanished. These observations I observe to be in accord with statements made by Professor Rosenbusch as to the contact rocks of Bar Andlau in Alsace.† These observations may be thus shortly summarised :—

It is evident that there is surrounding the great intrusive masses a zone of altered sediments, but this zone is not a zone of sediments enfolding the mass after the manner of an envelope. The sediments are discordant in their bedding to

---

* I cannot help suspecting that the colourless, doubly refracting plates, which in many cases are seen to form the ground masses of such slightly metamorphosed rocks as these, may be a mineral of the kaolin group in a crystalline form. This view has been strengthened by the observation that indurated, pale-coloured, upper Silurian mudstones in contact with an intrusive granitic mass at Kaffir's Hill, Foster, are seen under the microscope to be entirely composed of minute plates, which are probably orthorhombic. A qualitative examination of the rock showed it to be near kaolin in character.

† An inspection of the analyses of contact rocks from the normal Steiger schiefer to the granitite contact, given by Professor Rosenbusch (*Die Steiger Schiefer, &c., Strassburg,* 1877, p. 256), will show that "with increasing metamorphic intensity—with greater proximity to the granitite the percentage of water in the contact products decreases in a regular and visible manner."

the surface of the igneous rocks. Their directions of dip and strike are not only not in accord with the surface of the igneous rocks, but in the immediate contact the sediments are broken, crumpled, and cut off. These appearances of intrusion are most distinctly manifested when the contact crosses the direction of the strike of the sediments; while, on the other hand, the sedimentary beds when the direction of the contact and their strike coincide, are found to interlock in their most altered condition with the marginal rock masses of their intrusive neighbours. Such a contact may be imagined as I have roughly sketched it, and in its fea-

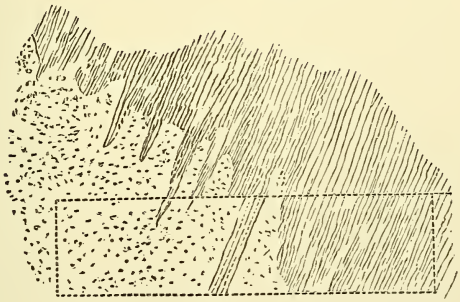

Diagram No. 4.—Representing the Contact.

tures it agrees with the observations which I have made as to similar contacts in other parts of Victoria. These appearances suggest most strongly to me, not only the intrusion of the plastic igneous rocks, but also as strongly the absorption, so long as the conditions remained the same, of portions of the invaded sediments; and further, that these processes must have been intermittent and of long duration. This contact zone is, as seen at the surface, of varying width. We should expect it to be so when we consider that the contact surface itself must be highly irregular, so that it must in places be far nearer to the present surface than elsewhere, or extend beneath it at varying angles with the horizon. From various approximate measurements, I believe the width of the zone from the main intrusive mass to those schists which are least altered, and wherein commences

the regional metamorphism, to be from twenty to sixty chains.

The several zones may be defined as follows:—

1st zone (intimately connected with the intrusive rocks), aplite.

2nd zone, hornfels (compact and schistose).

3rd zone, indurated, wrinkled or silky slates, and sandstone.

Of these, the first is by far the narrowest, and is only of local occurrence. No hard and fast boundary can be drawn between the second and third zones, as they are connected by varieties.

THE QUARTZ REEFS OF SWIFT'S CREEK.

	Name of Reef.	Locality.	Strike or Underlay.	Width of Vein in inches.	Depth of Workings in feet.	Amount of Quartz Crushed.	Yield of Gold per ton.	Remarks.
						tons. cwt. qrs.	oz.dwt.grs.	
1	Snow Storm ...	Swift's Creek...	...	20	30	40 10 0	0 1 12 0 5 22·11	The crushings were of 15 and 25 tons.
2	Himalaya ...	Ditto ...	...	...	...	...	...	
3	Sebastopol ...	Ditto ...	U. South, @ 70°	7—8	40	40 0 0	0 5 0	
4	Charlotte ...	Ditto ...	St. North ...	6—8	10	30 0 0	1 10 0	
5	Elizabeth ...	Ditto ...	U. West, @ 70°	2—12	30	90 0 0	0 6 15	These adjoin on the same line. Four tons subsequently gave at the rate of 4 oz.
6	New Fashion ...	Ditto ...	U. West, @ 70°	2—12	60	160 0 0	2 0 0	
7	Midas	Ditto ...	U. South, 85° W. @ 65°	2	...	...	...	
8	Wilson	Ditto ...	...	...	...	...	...	
9	Old Fashion ...	Ditto ...	U. West, @ 54°	2—6	...	...	...	
10	Morning Star ...	Ditto ...	...	12	35	24 0 0	1 2 0 0 10 20	Two crushings of 12 tons.
11	Iron Duke ...	Ditto ...	U. West, @ 70°	4—10	60	...	...	The shoot of gold dipped to the north and was 150ft. along the reef; wedged out in length and depth. No returns made known.
12	Hand-in-Hand ...	Ditto ...	...	4—7	...	...	...	
13	All Nations' ...	Eureka ...	...	14	...	...	...	
14	Power's	Ditto ...	St. North ...	30	...	...	1 0 0	
15	St. David's ...	Ditto ...	St. North ...	...	25	66 3 0	0 8 13·77 0 10 9·60	Ran out and became poor.
16	Eureka	Ditto ...	U. South, 80° W. @ 86°	...	142	1128 0 0	...	The yield varied from 4dwt. to 1oz. 2dwt. per ton.
17	Black Prince ...	Ditto ...	...	6	53	122 0 0	1 7 0	
18	United Miners' ...	Ditto ...	St. North ...	...	...	...	...	No returns made known.
19	Harry Evans ...	Ditto ...	...	1—5	...	1 10 0	...	No returns made known.
20	Renovator ...	Ditto ...	...	18—20	60	151 0 0	1 0 0 0 5 4·28	Two crushings of 28 tons and 123 tons.
21	Rob Roy ...	Ditto ...	St. North ...	6	100	671 0 0	...	The yield varied from 1oz. 4dwt. 2·18gr. to 7dwt. 14·60gr. per ton.
22	Found at Last ...	Riley's Creek...	St. North ...	6—12	35	104 0 0	...	The yield varied from 1oz. 13dwt. 4·24gr. to 11dwt. 18·81gr. per ton.
23	Commin's ...	Ditto ...	U. West, @ 57°	6—12	26	106 3 0	...	The yield varied from 1oz. 8dwt. 11·13gr. to 12dwt. per ton.
24	Little Wonder ...	Ditto ...	St. North ...	...	...	9 12 0	1 10 17·5	
26	Caroline (Duke of Cornwall)	Lower Swift Ck.	...	...	...	580 0 0	...	The yield varied from 8dwt. to 12 dwt. 11·73gr. per ton.
27	Try Again ...	Riley's Creek...	U. West, @ 70°	6—24	40	12 0 0	0 11 5	Wedged out.

CENTRAL PARK
NEW YORK

PART II.

4. The Alluvial Gold Deposits.

The alluvial gold workings have been carried on from the junction of Eureka Creek and Swift's Creek to the junction of the latter with the Tambo River: also in the Sheep Station Gully and in Riley's Creek, throughout almost the whole course of the latter. These deposits are now almost exhausted by the mining operations of the last twenty-five years. They were confined entirely to the stream bed, and more rarely to the points of the spurs. In tracing down Swift's Creek proper from Eureka and to near Tongeo West, I have found that the stream flows along the contact of the intrusive and the sedimentary rocks, and that it has cut down along this contact, whose plane dips at an angle of perhaps about 30° to 45° to the west. The streams which join Swift's Creek in this distance from the west flow only over sedimentary or metamorphic formation, and have not been found sufficiently auriferous to pay for working excepting in places near their junction with the main stream; and here the gold seems to have ceased in passing from the contact into the area of the altered slates and sandstones, as at Eureka. This points, therefore, to some connection between the contact of the intrusive and sedimentary formations and the source of the gold.

From Tongeo West to the Tambo River, Swift's Creek flows within the somewhat metamorphosed Silurian strata, and at an increasing distance from the intrusive granites, which are, however, most certainly situated at no great depth under foot. A connection between the gold and the intrusive rock masses is not so evident in this part of the district.

On leaving Swift's Creek and following up Riley's Creek it is found that gold has been extensively mined for in the stream for some distance above where the contact crosses it. A very rocky and precipitous part of the stream's course then ensues, in which little or no gold has been found. Near the junction of Sheep Station Gully with Riley's Creek the tableland known as the Gum Forest commences, and the fall of the stream being more moderate, gold has been

retained. From here the auriferous deposits extend only a short distance up the Sheep Station Gully, but have been continuous along Riley's Creek up to the point where it crosses the southern contact of the diorites and the Silurian formation, at which place the creek ceased to be payable. Throughout its course Riley's Creek follows more or less along the line of contact of some highly-altered sediments and the diorites which have intruded into and metamorphosed them. Sheep Station Gully, on the other hand, flows almost entirely on the quartz diorites. Here, again, we have an indication of some connection between the source of the alluvial gold and the contacts of the igneous and sedimentary strata.

I need not enter into fuller particulars as to the occurrence of the alluvial gold, which would be of little interest.

5. The Auriferous Quartz Veins.

Quartz reefs have been more or less mined upon at Swift's Creek for many years, but are now, with one or two exceptions, abandoned. I give a tabulated statement of all the data which I have been able to collect as to the width of the quartz veins, the depth to which they have been worked, the amount of stone crushed, and the yield per ton. The statistics which can still be obtained are unfortunately very scanty. Those given have been compiled from the returns published by the Mining Department, and from *viva voce* statements made to me by persons who have been engaged in working the several mines.* An inspection of these tabulated data and an inspection of the map show :—

1. The gold-bearing reefs, with the exception of the Caroline (now Duke of Cornwall), are all situated on or in immediate proximity to the line of contact of the intrusive and sedimentary rocks.

2. That they are narrow, and have become unproductive, or have "wedged out" at or under 200 feet from the surface.

The gangue of these reefs is almost invariably quartz, but rarely, as at Eureka, it was—for instance, in the Renovator

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* In collecting these statistics I must express the great obligation I am under to Mr. W. Phipps, mining registrar at Omeo, and to Mr. Thomas Easton, J.P., of Omeo, who was formerly engaged in mining adventures at Swift's Creek.

mine—partly composed of carbonates of lime, iron, and magnesia, derived, no doubt, from the decomposition of the soda-lime felspars and hornblende of the diorites.

In order to ascertain what inferences may be drawn from the reefs themselves, I propose to consider a few of the mines as to which I have made notes.

Eureka Reef.

This quartz vein is situated on a spur falling towards Eureka Creek. It has been somewhat extensively worked by adits put in from a gully on the south side of the spur. The last mining operations were carried on at the west side, where an adit was partly driven in intensely hard quartz diorite, but was abandoned before reaching the reef. No. 1 adit, which I examined, follows the course of the reef, which winds much, varying in direction from N. to N. 25° W. Its average direction is probably N. 20° W. The underlay* in the adit is westward at about 80°. I found the reef to vary very considerably, both in underlay and in strike. In following the reef the adit was at first on the east side, but near the end crossed and followed the west side—that is, the "hanging wall." At about this place was, I believe, the "shoot of gold" in which the main shaft was sunk. To the north of this point the reef is very narrow, or even only indicated by the walls and an inch or two of "mullock." In places there are small bulges of quartz. The same features occur in passing up the higher stopes to the surface. The reef is entirely in a quartzose diorite, but there are traces of contact schists close at hand at the Black Prince Mine, and the main contact is at a distance of 20 chains west.

The footwall of the Eureka reef is a dull greenish or almost colourless compact rock of a somewhat felsitic character. A microscopic examination showed me that it is composed of aggregates of quartz granules similar to those seen in the quartz diorites, filling in spaces between altered minerals, having the shape of felspars. These latter are composed of minute scales and twisted flakes, and more rarely of plates of a micaceous mineral—perhaps muscovite if the crystals were originally orthoclase, or paragonite or margarite if they were soda or soda-lime felspars.

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* I here use the mining term "underlay" as indicating the angle formed by the vein with the horizon, and the term "dip" solely in reference to the angle of descent of the shoot of gold in the direction of the strike of the reef.

These pseudomorphs polarise as bright-coloured aggregates. In examining these aggregates in the thinnest parts of the slices I found them to be filled in those interstices which may have represented planes of cleavage by numerous black or dark green flocks, the nature of which I could not determine, but suspect to be chlorite. The quartz granules contain countless numbers of minute cavities. They mostly contain fluid, and some have minute bubbles. Some cavities are, however, evidentally empty. I observed also many undeterminable microliths. The rock is strongly impregnated by ordinary pyrites in modified forms of the cube. This rock has, I think, been subject to great alterations, of a character different to that of surface decomposition.

In the quartz which forms the gangue of this mine I found arsenical and ordinary pyrites, and galena, as also small amounts of zinc blende.

According to Mr. Easton, of Omeo, who was well acquainted with the mine when being worked, the "shoot of gold" was from 30 to 40 feet along the course of the reef and dipped north at 66°—70°. It yielded from one to two ounces per ton of stone. He informs me also that the shoot was followed downwards to a depth of 130 feet when the workings were discontinued. The high yield quoted by this gentleman seems at the first glance to be inconsistent with the tabulated statements; but an examination of the mine showed me that much poor stone had been taken out far beyond the shoot of gold, and, in fact, a great amount of work done and money expended uselessly.

Rob Roy Reef.—This is situated at no great distance from the Eureka and Black Prince Mines, and immediately upon the contact line. The reef crops out along an extremely steep spur between the Sheep Station Gully and Eureka Creek. Adits have been driven at various times into the hill along its outcrop. The workings which were in operation when I visited the mine last were carried on by two adits. In the upper one the average thickness of the quartz vein was 6 inches. Generally speaking the reef has quartz diorite on one side and highly altered contact rock on the other, and underlies west at about 78°. To the southward where the reef leaves the contact and is wholly in the quartz diorite, it narrows to 2 inches, becomes poor, and then dies away.

The main workings at the time of my visit were in the lower adit about 100 feet below the surface, the width of the

reef then being as much as 15 inches, and it yielded about one ounce per ton. It underlies in this adit west at from 70° to 80°. The gold occurs in a vertical shoot of some 20 feet along the course of the reef. At the north end of the shoot the reef narrows very much, and in one place is quite wanting, there being then nothing remaining but the two walls almost in contact. To the southward of the shoot, so far as the workings extend, the reef does not wedge out, but becomes poor.

The following sketch will illustrate the position of the reef on the lower workings and in the centre of the shoot.*

Diagram No. 5.—Sketch of the Quartz Vein at the Rob Roy Mine.

a. Horse of silicious felsitic rock, containing much ordinary and arsenical pyrites.

b. Finely crystalline foliated contact rock, with a little pyrites. In places it is very micaceous.

c. White translucent vein quartz, about 8 inches in width, with arsenical pyrites (yields about 1 ounce per ton).

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* Mr. Forsyth, the owner of this mine, who has had great practical experience in the Swift's Creek reefs, said to me in speaking of them—"The reefs here, as a rule, always wedge out not far from the surface, and when they wedge out the walls are very hard." The bearing of these statements will, I think, be seen further on.

d. Quartz diorite.

Elizabeth Reef.—This reef is situated on the steep hill forming the south side of the valley of Swift's Creek, near the Charlotte Spur, and is near the present line of contact. It is in gneissic and granitic rocks, which, as I have pointed out, form the margin of the intrusive mass in many places. An examination of the neighbourhood showed me that although the actual contact is in the stream bed, and at some distance lower than and to the north of this mine, its plane originally extended along the hillside to the summit of the ridge, where traces of contact rock still exist as outliers, forming isolated nobs in the granitic ridge. The line of reef extending north and south from near the summit to the stream indicates that it fills a fissure penetrating through the contact rocks into the underlying intrusive masses.

When I examined the reef it was being worked. I found the shaft situated about 40 chains up the hillside from Swift's Creek. The reef near the surface had an underlay to south 85° west at 60°. It was 9 inches in width, with granitic walls. On descending the shaft between 30 and 40 feet, I found the appearances indicated in the subjoined sketch.

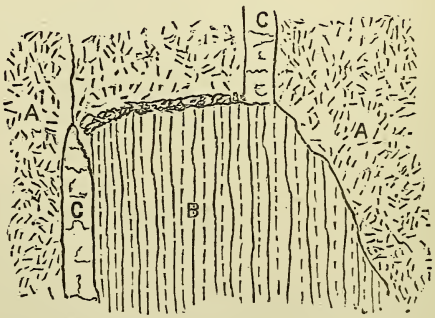

Diagram No. 6.—Sketch of the Quartz Vein at the Elizabeth Mine.

a. Coarse gneissic quartz diorite, very much decomposed.
b. Schistose hornfels.
c. Auriferous quartz vein.

The reef was here only 4 inches in width, and had a slight underlay to the east.

These examples may serve to illustrate the reefs of this district, with the exception of one at Lower Swift's Creek, formerly known as the Caroline, and now as the Duke of Cornwall. This reef is at a distance from the contact, in the nodular argillaceous schists and quartz schists which fringe the area of regional metamorphism.

I note the following as to this reef:—This quartz vein runs east and west, and thus forms an exception to the general rule at Swift's Creek. It crosses a spur from the range on the north side of the stream, and adits have been driven from both sides. Most work has, however, been done at the eastern end of the lode.

There are two parallel veins distant a few yards apart The veins vary in width. The quartz is somewhat glassy and crystalline. Pyrites is less frequent here than is the case in many other reefs of the district, and the gold is rather generally diffused in small particles than found in any defined "shoot." At the western end of the lode No. 1 adit was driven for 150 feet in the northern vein, the width of the quartz being about 22 inches, and having an underlay of about 80° north. Stone from this adit crushed from 6—8 dwt. per ton. The cap only of the southern vein at the western end was opened up, but a shaft was then sunk to 50 feet, the quartz being about 40 inches wide, and 15 tons of stone taken from this place gave at the rate of 8 dwts. 8 grs. per ton.

At the eastern end an adit has been driven for some 200 feet along the course of the lode, and the vein stoped out to the surface.

Returns given in the quarterly reports of Mining Surveyors and Registrars, published by the Department of Mines, show that the stone from these adits yielded at the rate of 11 dwts. per ton.

The mine is now idle. This vein has as yet never been thoroughly tested. It may probably extend to greater depths than any other of the reefs opened at Swift's Creek.

The quartz reefs of Swift's Creek may be classed as (1) those situated in the line of contact between the intrusive masses and the sediments, and (2) those situated in the regionally metamorphosed Silurian beyond the contact. I have shown that the former penetrate through the contact into the underlying quartz diorites; that they have been found to be richest near the surface, to dwindle away as they penetrate deeper, and to become less auriferous, or cease at

no great depth from the surface. It may, perhaps, be of some significance that, when the reefs discontinue, the dioritic rocks, as a rule, cease to be decomposed. Some few auriferous reefs have been discovered, and worked within the diorite area; but in these cases isolated patches of contact schists associated with them prove that the general absence of these rocks is in reality only due to denudation. The occurrence of these quartz veins in the decomposed diorites adjoining sediments is paralleled by the occurrence of auriferous quartz veins in decomposed or mineralised dykes elsewhere.

At Swift's Creek the auriferous and metalliferous quartz veins are evidently connected with a vast mass of intrusive and often granitic diorite. In other parts of Gippsland auriferous quartz veins are found in connection with dykes of similar mineral character. I take as instance the dyke and reef at Kaffir's Hill, Stockyard Creek, and the dyke and reef at Walhalla.

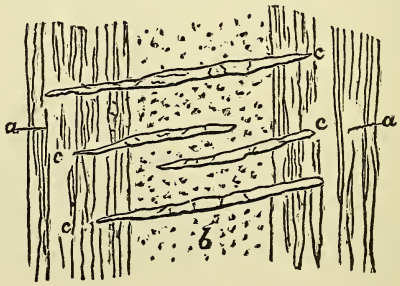

Diagram No. 7.—Dyke and Reef at Stockyard Creek.

(*a.*) Silurian (upper ?) mudstones.
(*b.*) Granitic dyke.
(*c.*) Auriferous quartz veins.

In this instance the auriferous quartz veins pass through the dyke, and penetrate the sediments on each side. The dyke, which is from a few feet to 200 feet in width, is almost completely decomposed; indeed, so much so as to rapidly crumble away when brought to the surface. The outline of porphyritic felspar crystals in a kaolinised state can be recognised in the more granular portion. No hornblende or mica is visible in this rock, nor could I determine whether any

secondary mineral products existed which could be referred to the alteration of these species. The compact portions of rock which were brought up from the mine, and came from the contact, seemed to me to be indurated mudstones; these, under the microscope, in thin slices, proved to consist of aggregates of minute scales, suggestive of an orthorhombic mineral. A qualitative examination pointed to kaolin. This dyke has not yet been worked to such a depth as to have reached the less altered stone. The gold is found in the quartz veins, extending into the slate country, which is also, together with the quartz, much impregnated by iron pyrites.

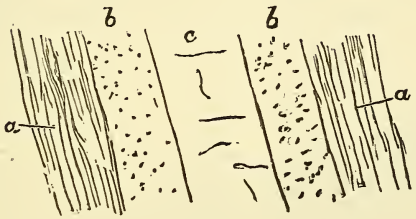

Diagram No. 8.—Dyke and Reef at Walhalla.

a. Silurian slates (upper ?).
b. Dyke.
c. Auriferous quartz veins.

In this reef, part of which is being mined by the well-known Walhalla and Long Tunnel Companies, the auriferous quartz lies, as a rule, more in the contact of the dyke and of the silurian slates than is the case in the instance just given. The dyke is a compact or fine-grained diorite of an almost felsitic character,* which is highly mineralised by arsenical and iron pyrites; but, as a rule, is rather indurated and mineralised than decomposed. Some slices prepared from samples of this rock—for which I have to thank Mr. Rosales, F.G.S., of Walhalla—showed me :—

1. Cryptocrystalline ground mass, in which crystalline grains of quartz were discernible.

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*Professor Ulrich calls this a "diorite-aphanite." See *Descriptive Catalogue of the Specimens in the Industrial and Technological Museum, Melbourne,*" 1875.

2. Spaces filled by alteration products, forming crystalline aggregates, in which quartz predominated. The smaller spaces had the form and presented traces of hornblende.

3. Crystals of arsenical and ordinary pyrites, surrounded often by crystalline quartz. This example shows distinct marks of alteration, and the Fe and As pyrites are evidently secondary to the injection of the dyke stone.

These instances illustrate the auriferous quartz veins connected with dykes. They might be much extended by references to Wood's Point and elsewhere; but these given will serve to show their mode of occurrence, and for comparison with the reefs of Swift's Creek. For comparison with the diagrams just given, I now subjoin one illustrating the manner in which I conceive the Swift's Creek reefs to occur.

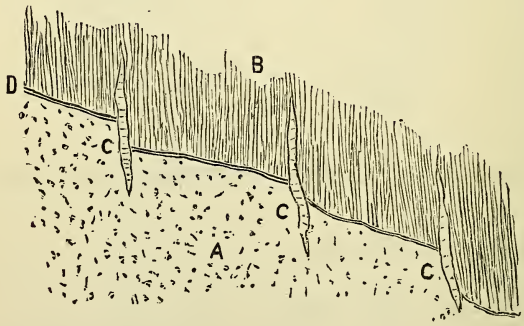

Diagram No. 9.—Contact at Swift's Creek with Quartz Veins.

(*a.*) The intrusive diorite mass.
(*b.*) The Silurian sediments (contact schists).
(*c.*) Auriferous quartz veins.
(*d.*) The plane of contact.

The plane of contact would give passage to heated waters or vapour accompanying the eruption of the diorites. It would probably resemble contacts between the subterranean masses of modern volcanoes and the adjoining sediments. It is in such contacts, and the fissures connected with them, that we may conceive metalliferous deposits to take place. In the case of Swift's Creek all the reefs, with one exception,

that have been mined upon comply with the requirements of such an hypothesis. The exception, as I have before said, is the Caroline Reef, which penetrates the nodular argillaceous schists at a distance from the granitic contact. Such fissures as those indicated would tend to pass upwards through the schists, but would not, I conceive, be found to penetrate downwards into the consolidated igneous mass.

Denudation and erosion acting along the contact would suffice by the wearing down of successive small auriferous veins to supply the large amount of alluvial gold which has been found at Swift's Creek.

In all the cases now given, including those at Swift's Creek, the bounding rocks, as well as the reefs themselves, are more or less highly impregnated by pyrites, which are often richly auriferous.* At Swift's Creek, in addition, there is locally some amount of sulphides of lead, copper, and zinc.

In the upper parts of the veins percolating surface waters and atmospheric influences have decomposed the sulphides, while below the water-level these usually remain unaltered. It has further, according to my experience, been frequently found that the amount of gold has been relatively larger in the vein above the water-level than below it. Two explanations might, I think, be given of the presence of the metallic sulphides and of the gold—(1) That the ores and gold had been collected in solution from the superior or from the bounding rocks; (2) that they had been transported in solution from below upwards. I think that a third alternative—namely, the injection of the ores and gold with the molten substance of the dyke—need not be considered. In either of the two former alternatives the vehicle must, I think, be held to have been water or water vapour.

If we were to assume that the gold and metallic ores have, together with the quartz, been deposited in these fissures from percolating surface waters which have abstracted them from the superior or bounding rocks, we must then further assume that this process is constantly operative to keep pace with unceasing denudition of the surface, and that a concentration of gold has taken place above the water level. If, on the other hand, we were to assume that the deposition of ores and gold took place with the quartz in these fissures

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* Tailings taken from Mr. Forsyth's mill at Swift's Creek gave, according to an assay by Mr. J. C. Newbery, at the rate of over 70 ozs. of gold per ton.

from waters not necessarily and immediately proceeding from the surface, but connected either as water or water vapour with the injection of the dykes or the intrusion of the masses, then those deposits below the water-level would be derived from below and from sources which cannot be at present pointed out, owing to want of data.* The metalliferous deposits below the water-level would then be contemporaneous with the formation of the dyke, while above the water-level the ores would have undergone changes due to the ceaseless reactions set up by meteoric waters, and a concentration of gold might take place. In fact, such changes as are indicated as being in progress at the Alison Mine, Costerfield, "where the highly saline water makes its way through the roof of a drive, and then deposits a mammillary crust of a brown colour, which, upon analysis, was found to contain hydrated oxide of iron, oxide of antimony, sulphide of antimony, gold and silica, with some alkaline sulphates and chlorides. As the block of ground is completely severed by workings in the course of the lode, the water must come from above, the strata on either side being dry."†

The second hypothesis is, I think, most in accordance with the facts observed as to the reefs in connection with dykes or intrusive masses.

At first sight these explanations would seem to be scarcely applicable to quartz veins of the second class—namely, such as are found in the silurian sediments unconnected with

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* A discussion of this question more fully would lead me into the consideration of regional metamorphism, which would be beyond the scope of this essay; but I may now point out that where sediments are invaded by igneous masses, before they have been re-elevated after their formation above the sea-level, the saline waters included in them during their deposition would supply not only a vast amount of heated water and water vapour, but also materials for the regeneration of the sediments as mica schist, gneiss, and granite. It may be broadly stated that the mineral constituents of sea-water are the complement of the sediments. The experiments of Dr. T. Sterry Hunt on the porosity of rocks proves how large an amount of saline water may be included in uncrystallised sediments, and thus become available, as I have suggested, for the regeneration of the sediments as metamorphic rocks, and to provide the alkali for the soda and soda-lime felspars. These triclinic felspars are a marked feature in the regional metamorphic schists of Omeo. Professor Rosenbusch has shown that in the contact schists of Bar Andlau the amount of water sensibly decreases as they become more crystalline in nearing the contact. (*Hunt's Chemical and Geological Essays*, p. 164. Rosenbusch's *Die Steiger Schiefer*, p. 256).

† J. Cosmo Newbery, B. Sc., Analyst to the Department of Mines. *Report of Progress of the Geological Survey of Victoria*, Par IV. p. 175.

dykes.* But they will be more applicable if we regard the fissures in such cases as penetrating the strata to varying, but as yet not ascertained, depths at which the igneous (granitic) masses underlie all Victoria.

On these views it would be reasonable to conclude that such contacts and fissures would, during periods of great igneous (volcanic) activity, give passage to heated waters and water vapours permeating the strata, and which, in passing through heated rocks, could carry minerals in solution and ultimately deposit them. "In these deposits we could recognise the mode in which the various metals were brought up from deep down in the earth's crust, and deposited in holes and crannies which are accessible to man as mineral veins."† If these views are well founded, and if, as seems to me, regional metamorphism and vulcanicity are intimately connected, we should expect that during all periods of volcanic activity or of metamorphism mineral veins should be formed.

In that part of the geological record which remains to us in Victoria, as exhibited in North Gippsland, we have evidence of volcanic action on a grand scale at the close of the Lower palœozoic ages, and in a less scale throughout the succeeding record until its abrupt termination at the close of the Devonian period. In Tertiary and in more recent times volcanic activity has left the plainest records for our study. Thus, if the views I have stated can be supported, we should expect to find a succession of mineral and auriferous veins commencing with the earliest regional metamorphism of the Silurian strata and extending onwards. Such a succession of veins I suspect there is, for they are found penetrating Silurian strata which are overlaid unconformably by Devonian sediments, and not passing upward into the latter. The discovery of an auriferous quartz vein at Freestone Creek in strata which are most probably of Middle Devonian age, and the occurrence of alluvial gold in situations which suggest that it has been derived from the Upper Devonian Iguana Creek beds, supports this belief. But the greatest number of auriferous veins seem to me to have been formed at the close of the Upper palœozoic age. In other

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* As at the Crooked River—*e.g.*, the Good Hope Mine.

† Professor Boyd Dawkins, as reported in *Chambers' Journal*, 31st May, 1877, at the Manchester Geological Society, May, 1877, when describing his visit to Vesuvius.

words, the production of auriferous quartz veins seems to have been in proportion to the igneous (volcanic) activity of the period.

General Conclusions.

I have endeavoured to state so fully the evidence in regard to the Swift's Creek district in its various geological, petrological, and mineralogical aspects that it is scarcely necessary to do more than to finally state the conclusions to which the careful consideration of this evidence had led me; and these conclusions are as follow:—

1. The intrusion of the Swift's Creek granites and diorites took place after the close of the Silurian and before the commencement of the Upper Devonian periods, and was probably connected with the volcanic activity of that time.

2. The Swift's Creek granites and diorites were intruded into the Silurian formations after the regional metamorphosis of the same, and the intrusion took place where the metamorphic change ceased.

3. The granites and quartz diorites were the earliest in time, and were followed by the more basic diorites and amphibole-gabbros.

4. The intrusive igneous rocks disturbed the sediments along the contacts, and partly absorbed them. They also effected a metamorphic change in them analogous to that effected by regional metamorphism. The contact metamorphism is most intense in the sediments immediately in contact with the igneous masses, and decreases in intensity outwards.

5. The metalliferous veins were probably produced at the time of the granitic and dioritic intrusions, and the lodes were formed in the contacts or in fissures connected therewith.

6. Denudation and erosion, which have laid bare the igneous masses, also set free the gold from the veins occurring in the contact, and thus supplied the alluvial gold deposits.

Note—Since writing this paper I observe that Mr. Daintree has arrived at somewhat similar conclusions as to the genesis of the auriferous reefs of Queensland. See Note on Certain Modes of Occurrence of Gold in Australia, by Richard Daintree, Esq., F.G.S., *Quarterly Journal of the Geological Society*, vol. xxxiv., p. 431.

EXPLANATION OF THE PLATE OF MICROSCOPIC DRAWINGS.

THE drawings were made by means of the camera lucida, and have since been re-drawn to one size for convenience.

1, 2, 3, 4, 5, 6, 7, 8, 9, 10. Examples of anorthite felspars from diorites and amphibole-gabbro, Riley's Creek.

11. (*a*) In this the plane of vibration is inclined 10° to the twin line. (*b*) This portion only shows zonal lines, and becomes obscured in a direction parallel to the twin line.

12. (*a*) Shows only zonal lines; the plane of vibration is inclined 9° to the twin line; (*b*) shows zonal lines and numerous twin striations in the lower half, the plane of vibration is inclined 12° to the twin line; (*c*) compounded of many narrow lamellæ (albite law), in which the planes of vibration are inclined 10° 30′ and 11° respectively to the common twin line and to the composition face. This slice appears to be inclined after the manner of a hemidome, and represents microcline and albite.

13. (*a*) These lamellæ become obscured in a direction parallel to the twin line; (*b*) in these lamellæ the plane of vibration is inclined 4° 30′ to the twin line. This is probably an alternation of orthoclase and albite.

14. (*a*) Crossbanded by wide lamellæ, cutting each other at angles of 94° and 86°; (*b*) simply compounded, the plane of vibration in the alternate lamellæ being inclined at 14° 30′ to the twin line.

15. (*a*) Very minutely crossbanded. The system parallel to the twin line becomes obscured when parallel to the plane of the polariser. The cross system becomes obscured at an angle of 5° 30′ to that direction. This half has been broken and cemented by quartz. (*b*) This half is only partially striated by narrow bands. The plane of vibration in the unstriated mass of *b* is inclined 14° 30′ to the twin line of *a* and *b*. These observations indicate microcline. From the gneissic quartz diorites adjoining the contact at Lower Riley's Creek.

16, 17, 18. Granules of microcline, parallel to the basis, from aplite, Swift's Creek.

19. Granule of microcline, probably parallel to the macropinacoid, from aplite, Swift's Creek.

20. Intergrowth of hornblende and pyroxene from Riley's Creek. (*a*) Colourless pyroxene (diopside), having an inclination of the plane of vibration of 44°; (*b*) green dichroic hornblende, having an inclination of the plane of vibration of 16° 30′.

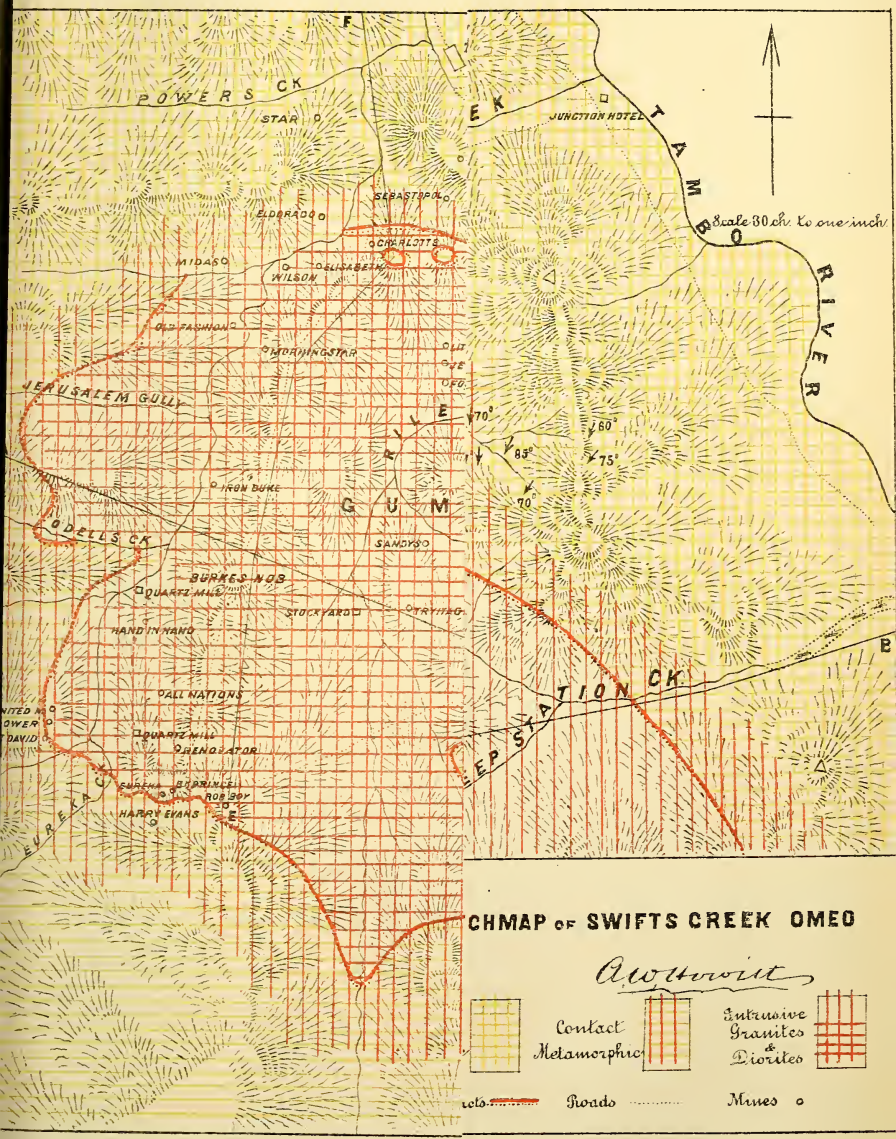
21. Chloritic alteration of hornblende. (*a*) Green dichroic hornblende; (*b*) green dichroic chlorite.

22. Chloritic alteration of hornblende. (*a*) Green dichroic hornblende; (*b*) green dichroic chlorite; (*c*) magnetite.

23. Intergrowth of mica and hornblende from the anorthite diorite, Sheep Station Creek Gap. (*a*) Dark brown dichroic magnesia mica, showing the basal cleavage; (*b*) the same mica seen in the direction of the axis *c*, brownish-red, not dichroic; (*c*) dark-green dichroic hornblende. The mica has a small optic axial angle, and is probably phlogopite.

24, 25. Chloritic alteration of magnesia mica. (*a*) Dark-brown dichroic magnesia mica; (*b*) fibrous green chlorite, dichroic in shades of metallic green; (*c*) magnetite.

CENTRAL PARK
NEW YORK
NATURAL HIST



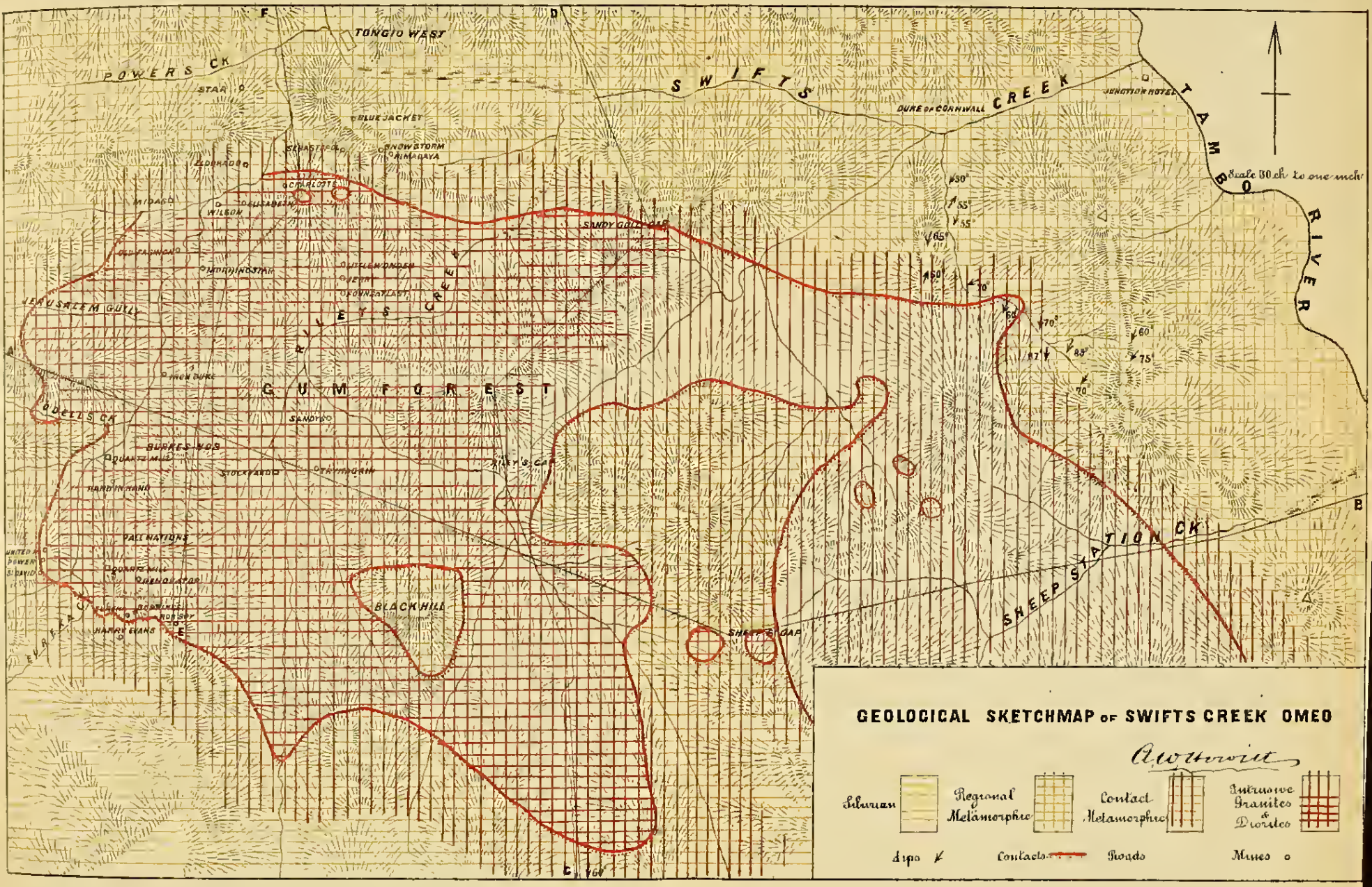
CHMAP OF SWIFTS CREEK OMEO

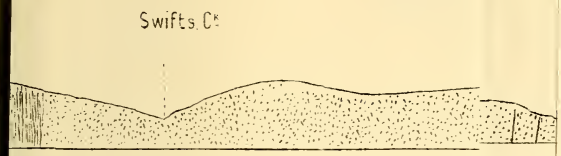
A. W. Howitt

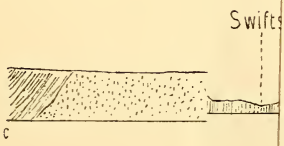
Contact Metamorphic

Intrusive Granites & Diorites

ets. Roads Mines

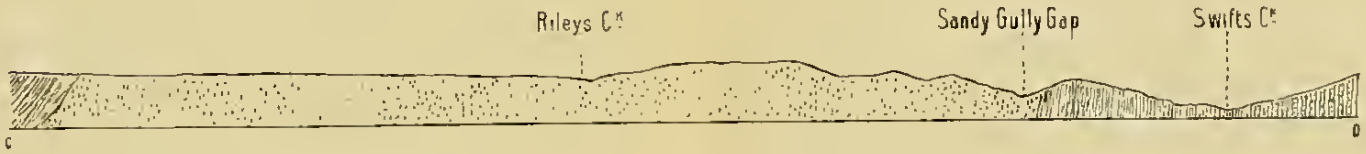

GEOLOGICAL SKETCHMAP OF SWIFTS CREEK OMEO
A. Wilkinson
Silurian
Regional Metamorphic
Contact Metamorphic
Intrusive Granites & Diorites
Dips
Contacts
Roads
Mines
Scale 30 ch to one inch
TONGIO WEST
POWERS CK
STAR
BLUE JACKET
SNOWSTORM
PIMADAYA
SENASTOPOL
ELDORADO
CHARLOTTE
MIDAS
WILSON
LUCIANA
SWIFTS CREEK
DUKE OF CORNWALL
JUNCTION HOTEL
TAMBO RIVER
SANDY GULLY GAP
GOLD FIELDS
MORNINGSTAR
GLENDONDER
VIEW
COUNTY CLARE
JERUSALEM GULL
EYES CREEK
IRON DUKE
GUM FOREST
SANDY
DOCKS CK
BURKES NOS
QUARTZ HILL
STOCKYARD
OTTINGHAM
RILEY'S GAP
HAND IN HAND
FALL NATIONS
UNITED POWER
ST DAVID
QUARTZ HILL
GREENLAND
BLACK HILL
HAPPY GLANS
SHEEP STATION CK
SHEEP STATION GAP
A
B
C
D
E
F





REGIONAL METAMORP.

Section from the Tambo River to Upper Swifts Creek.



Section from Swifts Creek to Rileys Creek

Section Eureka to Swifts Creek

Scale Horizontal 80 Chains to One Inch. Vertical 4000 Ft to One Inch

Regional Metamorphic Schists *Contact Metamorphic Schists* *Granites and Diorites*

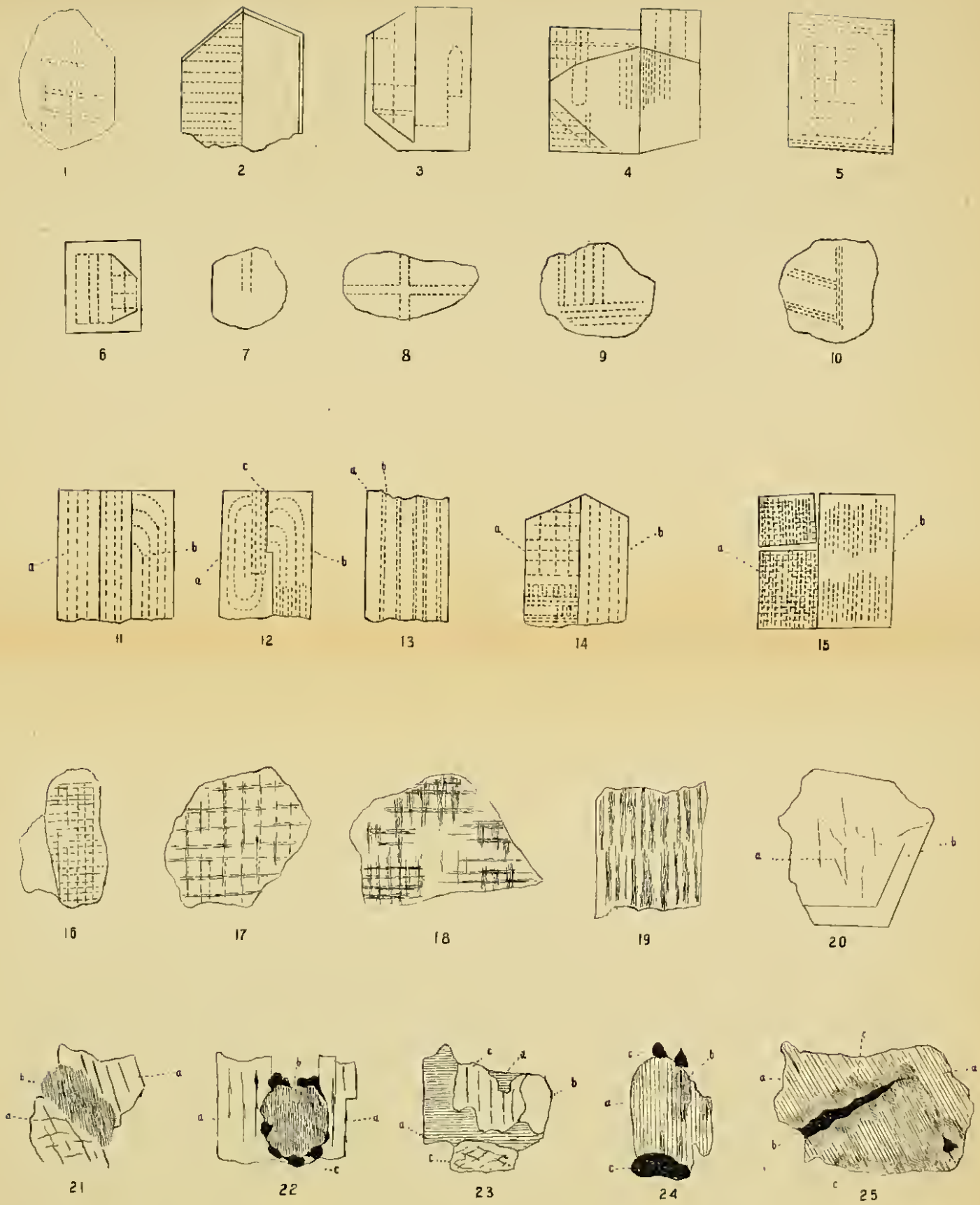
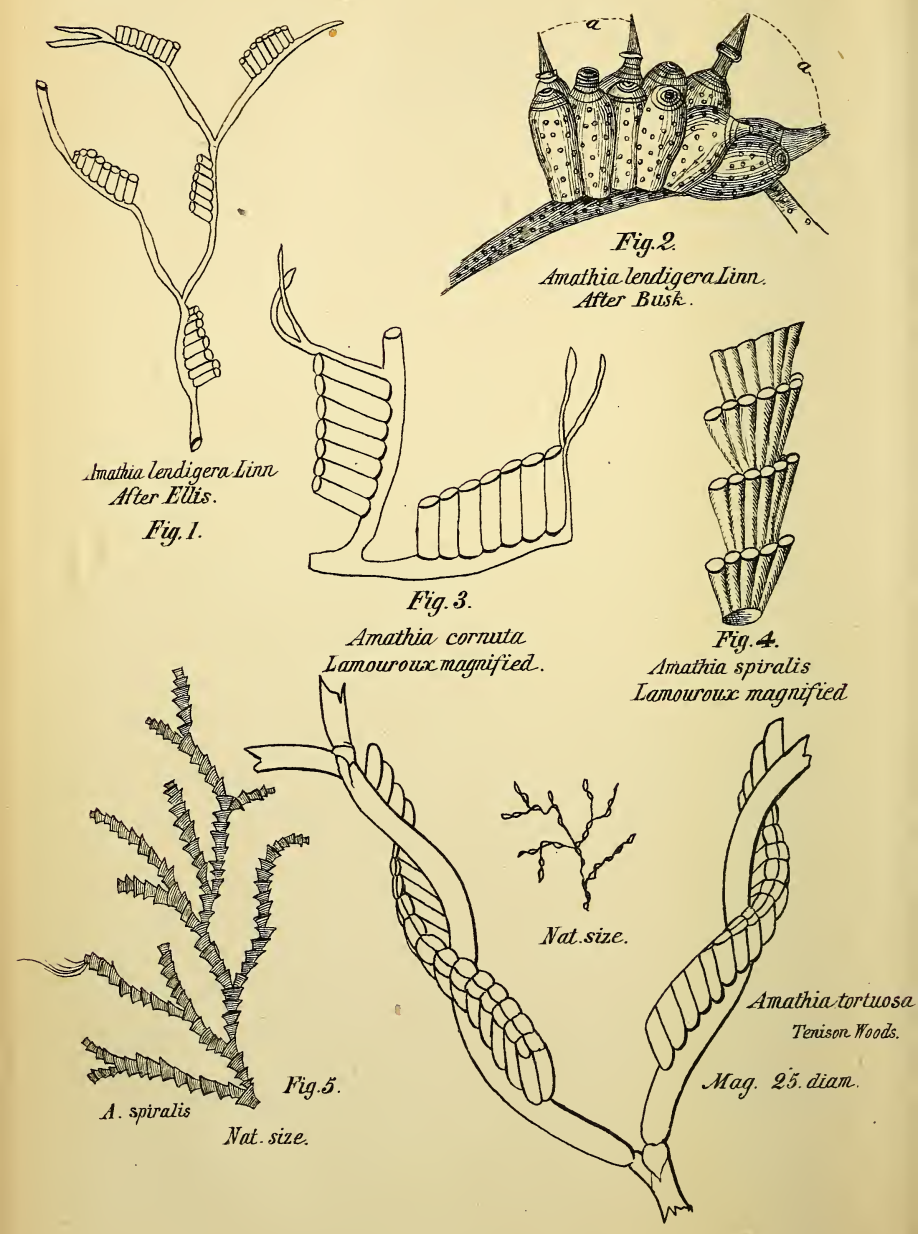


Plate of Microscopic drawings to accompany the "Diorites and Granites of Swifts Co &c"

NEW YORK


a
a
Fig. 2.
Amathia lendigera Linn.
After Busk.
Amathia lendigera Linn
After Ellis.
Fig. 1.
Fig. 3.
Amathia cornuta
Lamouroux magnified.
Fig. 4.
Amathia spiralis
Lamouroux magnified
Nat. size.
Amathia tortuosa
Tenison Woods.
Mag. 25. diam.
Fig. 5.
A. spiralis
Nat. size.

Art. IV.—*On the Genus Amathia of Lamouroux, with a Description of a New Species.*

By the Rev. J. E. Tenison-Woods, F.G.S., F.L.S., Corresponding Memb. Roy. Soc., Victoria, and President of the Linnean Soc., N. S. Wales, &c., &c.

(With a Plate.)

[Communicated 12th June, 1879.]

In 1877 (4th July) I described to the Royal Society of New South Wales two new species of *Amathia*, under the name of *Serialaria*, which were found on the coasts of Victoria. I have now the honour to draw attention to another undescribed species recently obtained in Port Jackson. It was found by the curator of the Sydney Museum (Mr. E. P. Ramsay) in the systematic dredging operations in which he has been recently engaged, and which have revealed many new forms of marine life. It is to be hoped that before long similar investigations will be carried on in other colonies. Large and important discoveries must infallibly result from them, not only extending our knowledge of the Australian fauna, but also throwing light on the paleontology of our extensive tertiary formations. In this hope we are encouraged by the valuable facts, both for the living and extinct fauna, which even our few dredgings have already revealed.

Class Polyzoa.

Order.—Infundibulata; Sub. Or., 3 Ctenostomata, fam. Vesiculariadæ.

Genus.—Amathia, Lamouroux (Bull. Phil., 1812, Histoire Polyp. Flex., 1816, 157); Serialaria, Lamarck.

Amathia tortuosa, n.s. S. Polyzoary, of a dark and dull olive green colour, in very fine, thread-like tufts; erect; not encrusting or parasitic; about two inches high, dichotomously branching, leaving rather long, slender, cylindrical, smooth, unarmed internodes, which are almost entirely occupied by a double series of about twenty-four pairs of rather high, narrow cells, forming a spiral of not quite one turn round the branch; mouth of cells somewhat crescentic; no setæ, spines, or armature of any kind.

This species, which was dredged at various depths from 2 to 16 fathoms, differs from all species known to me in the great length of the pairs of cells in each internode, in the long and slight spiral, and in the absence of any spines or processes.

I take this opportunity of reviewing the whole of the described Australian species, with a notice of the claims which the names bestowed by Lamouroux have upon our attention at the present time.

Flexible Polyzoa, formerly known, and perhaps at the present day more commonly known by the name of Zoophytes, have long occupied the attention of naturalists. The history of the various ways in which they have been regarded is not the least interesting part of the bibliography of natural history. It is not my purpose to go into any details in this part of the subject, which one can see dealt with by Lamouroux *(Polypiers Flexibles, par J. F. V. Lamouroux,* 1 vol., 8vo, 19 plates; Caen, 1816), or by Messrs. Edwards and Haime in their historical introduction to the *Histoire Naturelles des Corallaires* (3 vols., 8vo; Paris, 1857.)* It is sufficient just briefly to mention the main facts. Marsilli was the first who devoted himself in a special manner to these organisms, which he regarded as plants, in which he was followed by Reaumur, Lemery, and Geoffroy, who also published observations upon them. Aldovrandus, in 1548, and after him every naturalist until Peysonnel, in 1727, considered all corals and coral animals as vegetable substances. When the latter sent his memoirs to the Academy of Sciences it was disputed by all the learned of his time. He made his first observations at Marseilles, in 1723, and he continued them on the Barbary coast, and then at Guadeloup. He sent them to the Royal Society of London, but it was not until 1752 that they were translated by Watson, the botanist, and published in the *Philosophical Transactions.* The subsequent discoveries of Tremblay entirely melted away whatever doubts there were on this subject. By the time that Linnæus began his work he, with others, seemed still to doubt the animal nature of corals. That illustrious zoologist called them hydras, because of their form. Reaumur, now entirely converted to the views of Peysonnel,

* There is also an excellent history by Johnston in his *British Zoophytes,* first edition, 1838, written with all the learned vivacity of one of the best English writers on natural history.

called them Polypi. The French Royal Academy of Sciences, wishing to establish the discoveries beyond a doubt, commissioned Bernard de Jussieu and Guetard to make special examinations of marine animals upon the coasts of France. Guetard (says Mons. Lamouroux) ought to be classed amongst the naturalists who have written most upon Polypi; but he is hardly cited by modern authors, although his memoirs are printed in many collections. Though principally engaged upon the fossil forms, he did not neglect those existing in the present day. His two essays on sponges include all that has been written on the subject from the times of Aristotle to his own.

Linnæus commenced to study Polypi in 1744 or 1745. It was he who employed the name of Zoophytes, while his descriptions give grounds for the suspicion (says Lamouroux) that he regarded them as intermediate between plants and animals, and partaking of the nature of both. He was, however, the first who tried to establish definite principles on which their study could be pursued. The method that he established for their classification has been followed, or has served as the type for all who followed him. He determined the principal *genera*, and augmented the number of species, and finally rendered as much service to this province of zoology as he had done to botany by stripping it of all its cumbrous apparel of phrases and synonyms, which rendered its study so difficult and so disheartening.

Lœffling, Butner, Donati, and Roësel published their memoirs about the same time; but all contemporary works sink to insignificance by the side of that of our countryman, Ellis (*An Essay towards a Natural History of Corallines;* London, 1754, 39 plates), a translation of which appeared in France the year following. No work ever gave such an impetus to the subject. It was hailed with acclamation by every zoologist on the continent, both for the fidelity of its descriptions and the beauty and accuracy of the plates. He published subsequently a number of papers on different coral animals and Zoophytes, which are to be found in the 49, 50, 51, 52, 53, 55, 57, 58, and 66 vols. of the *Philosophical Transactions.* Ellis died in 1776, and up to the time of his decease was engaged on another elaborate work, for which many plates had been engraved. It was edited subsequently by Solander* (a pupil of Linnæus) and Sir Joseph Banks,

* Solander died before the work was finished, and it was completed by Ellis's daughter.

under the title of *Natural History of many Curious and Uncommon Zoophytes.* The first six plates of this work were lost after the death of Ellis; the only proofs of them, taken before lettering, are to be found in the Library of the British Museum.

In 1766 was published the *Elenchus Zoophytorum,* by Peter Simon Pallas, in which he united all that had been done before his time, enriched with many valuable observations of his own. He described a large number of new species.* In spite of his belief that Zoophytes were to be considered rather as vegetables than animals, Lamouroux justly calls this the breviary of zoologists who study Polypi. Muller, in 1776, in his *Prodromus,*† gave a description of many Polyzoa, which he subsequently figured, and was followed in this department by Otho Fabricius in his *Fauna Grœnlandica.* I pass over many names—such as those of Parsons, Baxter, Forskæal, Marratti, Dicquemare, Esper, Spallanzani—to come at once to that of Cavolini,‡ whose work, entitled *Memorie per Servire alla Storia dei Polipi Marini,* Naples, 1875, was a valuable contribution to the literature of the subject.

Gmelin, the editor of the thirteenth edition of the *Systema Naturæ* of Linnæus, has made a valuable compilation of all the previous authors, so that the volumes form a very useful epitome at least of the bibliography of the subject. It is a work very commonly met with, as well as the English translation of it in seven volumes by Dr. Turton.§

To Brugière, a physician who was botanist and naturalist to Louis XVI. of France, was entrusted the article *Vers* of the *Encyclopedie Methodique.* This work is justly con-

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* He was born in Berlin, in 1741, and commenced his zoological labours at Leyden, where he published his remarkable work. It is an 8vo volume, without figures, but these were added to a Dutch translation by Boddaert, published at Utrecht, in 1768.

† His work is entitled *Zoologiæ Danicæ Prodromus,* but a much more important edition appeared subsequently. This was the *Zoologia Danica,* only the first two volumes of which appeared during his life time. The third was published by Abilgaart, in 1789, and the fourth by Rathke, in 1806. The work is one of the very finest in the department of natural history which appeared in those days. It is illustrated by 160 coloured plates. Otho Fred. Muller was born at Copenhagen in 1730, and died at the early age of fifty-four.

‡ Philippe Cavolini, Professor of Natural History at the University of Naples. Born, 1756; died, 1810.

§ Twice since I have been in the colonies I have seen both these works offered at bookstalls for a few shillings. The work of Gmelin, being in Latin, was offered for 5s., and found no purchaser.

sidered one of the glories of scientific literature in Europe, and being undertaken on such an immense scale, it is truly wonderful, amid the wars, revolutions, and convulsions to which Europe was then subject, how it was ever brought to a conclusion.* In those days of the Linnæun classification *Vers* (or worms) included an important portion of the animal kingdom. *Insecta* and *Vermes* were the two grand divisions of the invertebrate animals. In the latter the testaceous mollusca occupied an order by themselves. The naked tribes were placed in another order along with radiated Zoophytes—annelids, parasitical worms, and the echinodermata. Brugière's part of the volumes was terminated at the word "cone," which completed the first volume of his contribution. He never lived to finish another. He started, in company with the naturalist Olivier, to visit Asia Minor, in order to enrich his work with fresh observations; but he died before this undertaking was completed. The greater part of his notes were subsequently lost in consequence of the premature death of his companion. Brugière attempted an improvement on the system of Linnæus. He divided the *Vermes* into six orders; in the last of which he placed the Zoophytes. He adopted the old genera without proposing new ones. He gives a complete history of the species; and Lamouroux says his synonomy is more exact than that of Gmelin. His efforts in the way of systematising carried zoology onward some steps. He made a distinct class of the star-fish and sea-urchins, under the name of echinodermata (see *Tabular System of the Vermes*, p. 6).

Except for the observations of Renier, Poiret, and Olivi, nothing seems to have been done for the Polyzoa until the time of John Baptist de Lamarck. This most remarkable naturalist was born in Picardy, in 1749. He distinguished himself first in a military career, and then applied himself to the study of medicine, which he soon quitted to devote himself to botany. His first work was the *Flora Francaise*, which appeared in 1773. Another edition, augmented considerably by Alphonse P. de Candolle, appeared in 1805; and a third, with a sixth supplemental volume, in 1815. In 1788 he was attached as botanist to the king's collection; and when this establishment was amalgamated under the

* It is a work of over a hundred volumes. The only Australian copy known to me is in the Melbourne Public Library, presented by Mr. Macgregor, M.L.A.

new title of the Museum of Natural History, he was appointed to a professorship of zoology. He was then fifty years old, being one of the few fortunate eminent men who came through the French Revolution with their heads on their shoulders. He devoted himself with great ardour to the study of zoology. He gave a new classification of the Polypi in his first edition of the *History of Invertebrate Animals*, which is an analysis of his lectures at the museum. He regretted the name of Zoophytes, as being unphilosophical, there being no such thing in nature as animals and plants combined. It may be questioned, however, whether plant animals in some sense are not admitted by men of science at the present day. Lamarck contributed very much to the knowledge of the Polyzoa during his life, which closed when he had reached the goodly term of eighty-five years. For the last few years he was quite blind. In his *Philosophy of Zoology*, published in 1809; in his extracts from the *Cours de Zoologie*, published in 1812; in his *Memoire sur les Polypiers Empatés* (1813), and on the *Polypiers Corticiferes* (1815), he made several changes in the classification. I shall deal with this question presently; but I wish now to mention the circumstances which brought the Australian Polyzoa prominently into notice. Up to the close of the last century it was the opinion of naturalists that Polyzoa and small corals and corallines (algæ) did not exist except in the European seas. It was a natural conclusion, derived from the fact that none were brought to Europe from foreign shores. Collectors busied themselves with the large and attractive specimens, and did not trouble about minute things. It was M. Bosc, in his different works, but principally in his *Natural History of Vermes*,* who combated this mistake. He studied the animals of many Tubulariadæ, Sertularia, and Alcyons, obtained from the floating weed of the Sargassum Seas of the Atlantic. On the coasts of Carolina, in America, he observed the growth of Gorgonia. He was the first who had the hardihood to say that the East Indian oceans contained Polypi similar to those of Europe, but he only advanced this opinion upon analogy. It was soon confirmed by the collections of Commerson and Sonnerat. But the most important contribution was that of Peron and Lesueur. These

* Printed in 1802, the 18mo edition of works of Buffon, known as the edition of Déterville.

were the naturalists to the French exploring expedition made in "Le Geographe" and in "Le Naturaliste," under Admiral Baudin, in 1800. They visited the whole of the south coast of Australia and Tasmania in 1801-2, and returned to Europe with the largest collection of Australian objects of natural history ever, perhaps, brought home. They could not have come at a more opportune time. Lamarck, Cuvier, Defrance, Delessert, Persoon, Risso, Labillarchiere, Desfointaines, Dumeril, and Lamouroux were, some of them, in the midst, and others in the commencement, of their labours; and it is to their works we must look for much information about the zoology of our continent. Lamouroux speaks in warm terms of eulogy of Peron, who, he said, was carried away by a mournful death just as he was about to reap the fruits of his labours. He was not long at home before he read to the Institute of France a paper on some new facts in zoology, by which he strove to prove by the difference between the people of Australia and Tasmania that their separation must date back to a very remote period. The fossil corals and shells which he found on the southern portion of the continent seemed to him to him to be analogous to those still existing in the neighbouring seas. He regarded this as a proof of the long duration of the waters of the Southern Ocean over this continent. This fact is an interesting one in our scientific annals. I believe this is one of the first records of any scientific observations on our tertiary formations. Tertiary geology, as such, was not known in those days. If it had been, Mons. Peron would have been able, perhaps, to perceive that the fossils he found were very different from any forms at present existing in our seas.

Peron, also, was the first to prove that no large species of solid coral was found beyond the 34th degree of south latitude. Further south than this he states that he found only *Gorgonia*, sponges, *Isis*, &c. He says, moreover, that this rule, noted first by him in the northern hemisphere, was found to be equally applicable to the southern, which he confirmed by bringing home a rich supply of specimens, and about a hundred species of Polyzoa, mostly new to science.

After the death of Mons. Peron, his work was in part carried on by M. Lesueur, in conjunction with Mons. Desmarets. The Polyzoa were handed to Lamarck for description, who allowed the fullest access to them to J. F. V. Lamouroux. This illustrious naturalist was born at Agen,

in Languedoc, in 1779, and was at first a shopkeeper; but from the assiduity with which he gave himself to the study of botany, was nominated Professor to the Faculty of Sciences at Caen. His first work of any pretension is the *Histoire Generale des Polypiers Coralligenes Flexibles*, 1 vol., 8vo; Caen, 1816. Another amended work, entitled *Exposition Methodique des Genres de l'Ordre des Polypiers*, was published in 1821, and in this we find reproduced the beautiful plates of Ellis, which Solander edited.* There has been but scant justice done to Lamouroux, and his engravings have been found fault with. For my part, I must say the figures seem to be excellent, and executed with fidelity. For the smaller species, no doubt, allowance must be made for the imperfect microscopes at the disposal of naturalists; and thus, it may be, that the more minute organs were misunderstood. It may be, also, that some of the species will never be recognised. On the whole, every one must admit that the work of Lamouroux is one of the very valuable contributions to the knowledge of Polyzoa which appeared in the commencement of this century. It is not my intention to institute a comparison between his work and that of Lamarck. As far as the value of the systems goes, this has been very ably and satisfactorily done by Dr. George Johnston, in his admirable *History of British Zoophytes*, Vol. I., p. 446.† It is sufficient for us to know that neither system is followed now, though the names of Lamarck for the most part survive. In one respect, however, I think that the accuracy of Dr. Johnston seems to be at fault. He places the system of Lamouroux with the date 1821 above it, and the system of Lamarck with the date 1816; but the first publication of Lamouroux was long anterior to that of Lamarck. The history of it is this:—In 1810 Lamouroux presented his first memoir on this subject to the Institute of France. In 1812 he sent to M. (afterwards Baron) Cuvier the duplicates of his collection, and he named the collection of M. de Lamarck for him, and, as he himself says, communicated his observations to several friends of his who were naturalists. In 1813 he sent to Mons. Bosc a more complete system of classification for

* Lamouroux died in 1825. Blainville, who blames his drawings, was not above copying a good many of them.

† A book which is almost as useful in Australia as in Europe. Full of observations of the highest interest. London, Van Voorst; 2 vols., 8vo, 1847.

these animals, in order that it might be submitted to the examination of the members of the academy. A commission was appointed to examine this, and the system was approved of. In three different reports, and in an analysis which Baron Cuvier made in 1815, the author was requested to publish his work as soon as possible. This he did in 1816, but his system dates many years before that of Lamarck on these organisms had seen the light. Now, though in his subsequent edition of 1821 Lamouroux made some additions and changes, yet the bulk of his generic names and definitions were made before those of Lamarck, and, therefore, he is entirely entitled to priority.* In the first section of his flexible Polypi we have five orders. In the fourth—the Sertularians—we have the following definition:—Sertularieæ.—Polypidoms phytoid, with a distinct or branched stem, rarely articulated, almost always fistular, full of a gelatinous animal substance, in which the lower end of each polypi is fixed in a cell whose position, form, and size is variable. In this order we have the following *genera:—Pasythea, Amathia, Nemertesia, Aglaophenia, Dynamena, Sertularia, Idid, Entalaphora, Clytia, Laomedea, Thoa, Salacia, Cymodocea, Amphitoita.* All these, with the exception of the last and *Entalaphora,* were named and defined before 1816. The second of them is *Amathia,* which is thus defined:—

Amathia†.—Polypidom ramose, cellules cylindrical, elongate, united in one or many groups. (Extrait d'un memoire sur la classification des Polypiers, coralligenes, non entierement pierreux, presente a la premiere classe de l'Institut de France, en Fevrier, 1810, par M. Lamouroux.") But the definition of this particular *genus* was in Nouveau *Bulletin Philomatique,* December, 1812.

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* Monsieur Blainville admits this; and I believe he was the first naturalist who gave Lamouroux the credit of the species which he named—a credit which Lamarck, who used his names, did not acknowledge. In the second edition of Lamarck, Messrs. Edwards and Deshayes, who edited this portion conjointly, did not admit Lamouroux's claims. I believe I am safe in saying that all this portion of the work was done by Milne Edwards, who does not seem to have examined Lamouroux's work closely. Blainville says:—"This division *(Serialaria)* of Sertularians has been established by M. de Lamarck and M. Lamouroux, almost at the same time, under different names. I have preferred the name chosen by Lamarck to that of *Amathia,* employed by Lamouroux, as more expressive and more in harmony with the other *genera* dismembered from the Sertularians." —*Manuel d'Actinologie,* p. 476. He thus quietly passes over the question of priority.

† Etymology.—One of the Nereids, according to Homer. Query.—From ἄμαθος—sands of the shore.

The following is a translation of the remarks of Lamouroux on his *genus*:—"*Sertularia (Auctorum), Amathia lendigera* (*Sertularia lendigera* of Linné) is the only species of this *genus* mentioned by authors. All have regarded it as a *Sertularia,* although the figures given by Ellis, Cavolini, and others, ought to have sufficed to separate this Polype from the *genus.* The *Amathias,* by their numerous cells, by their horny stem, which is fistulous and filled during life with an irritable gelatinous substance, present the general characters of all the Sertularia. They differ from the Polypi of the order by their general *facies,* their ramification, the form of the cellules, and their respective situation. In some species the cellules are united into isolated groups, which resemble Pandean pipes, with tubes of variable length. In others, all the groups touch, but are easy to distinguish by the unequal length of their cells. Some present all their polypiferous chambers united by their sides, and forming spiral salient lines around the stems, to which they adhere by their lower portions. Finally, there are some in which the lines of cells are not projecting from the front, but are attached to the stem by the posterior part of the cellules. Thus, notwithstanding the difference which is observed between *A. lendigera* and *A. spiralis,* it is impossible to erect special *genera* for them, as there are intermediate species which connect those which at first sight appear so very distinct.

"No specific character can be derived from the distance by which the cells are separated from one another. In *A. lendigera,* so common in our seas, we find individuals in which all the groups touch, and others when the same groups are four or five millimetres apart. In the number and the form of the cells of each group, in their situation, ramification, &c., we find the characters by which the species can be distinguished. The Amathias are of a horny substance, which is only slightly calcareous. Their colour is a more or less deep yellow brown or fawn colour. Their size varies from 1 to 15 centimetres. They are often found parasitic upon Thallasiophytes; sometimes they adhere to rocks and other solid marine objects by a fibrous attachment. They appear more common in the temperate or equatorial regions, than in the icy or cold regions of the poles. They are not used for any purpose."

Lamouroux goes on to describe the species, and I shall give his diagnosis and synonomy in his own words:—

265.* *A. Lendigera.*—Ramose, filiform cellules with an entire margin; groups at unequal distances, which are sometimes great. *A. Lendigera; articulata, sub-dichotoma, implexa; denticulis cylindricis, secundis, parallelis, ad genicula minoribus; ovariis* . . . . Sol. et Ell., p. 52, n. 25 (Sertularia); Pall. Elen., p. 124, n. 73; Gmel., syst. nat., p. 3854, n. 20; Bosc. 3, p. 99; Rai. Syn., p. 38, n. 3; Ell. Coral., p. 43, n. 24, fig. 6, B., tab. 15; Cavoll. Pol. Mar. 3, p. 229, tab. 9, fig. 1, 2; Esper Zoop., tab. 9, fig. 1, 2, European seas. (Cavolini gives very interesting details on this species.) To these must be added, from Deshayes and Johnson—Lamouroux Expos. Meth., p. 10; Ency. Meth. Zooph., p. 43; Schweigger Handb. der Naturgeschichte, p. 426 (as *Serialaria)*; Lam. Hist. Nat. d. Anim. s. vert., first edit., March, 1816, Vol. 2, p. 130; Cuv. Reg. Anim., second edit., tom. 3, p. 301; Fleming Brit. Anim., p. 547. *Sertularia lend.*—Delle Chiaje. Anim. senza. vert. di Napoli., t. 4, p. 146, pl. 63, fig. 6, et 16; Oliv. Zool. Adriatic., 289; Turton's edit. Gmel., Vol. 4, 682; Berk. Syn. 1, 218; Stew. Elem., Vol. 2, 445;† Wern. Mem., Vol. 1, p. 564; Turt. Brit. Faun., 215; Bosc Vers., t. 3, 117; Hogg's Stock, 33; Lister Phil. Trans., an. 1834, 384; Lam. Desh. edit., 2, 169; Risso. Eur. Merid., 5, 315; Stark Elem., 2, 439; Templeton Mag. Nat. Hist., 9, 467; Couch Zooph. Cornw., 37; Blainville Actinol. 476, pl. 83, fig. 2; Couch Cornw. Fauna., 3, 94, pl. 16, fig. 4; Busk. Eng. Cycl. Art. Polyz., Vol. 4, p. 430, Serialaria genus; Tenison-Woods Proc. Roy. Soc., N.S.W., 1877 (Vol. 11), p. 83.‡

266. *A. cornuta.*—The largest cellule of each group, with a free margin, furnished with two setaceous appendages.

A. c.; 2 *filamentis setaceis ad cellulam primariam.* On *Fucus* in Australasia.

Serialaria cornuta.—Lamarck, first and second editions, but with a reference to Lamouroux only, by Mons. Deshayes

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* The numbers refer to his own list of species.

† The number of Polyzoa described in this work is considerable, and it is particularly useful for its Latin glossary.

‡ I have figured here Busk's drawing of the cells of *A. lendigera*, from which it would seem that the cells are grouped, and not a single series, as represented by all previous observers. This fact should convince us that unless we have the type specimens it will be impossible to identify any of the old species. First of all the descriptions are too brief to be any guide; and, secondly, the imperfect microscopes of that time render the figures untrustworthy. It is astonishing how one author follows another without question. Cavolini, Esper, Blainville, and even Dr. Johnston, all copy the figures of Ellis, which represent a single series of cells.

in the second edition, with these words added—Mus. No. Hab. (?), Asiatic Ocean. I believe it came from the voyage of Messrs. Lesueur and Peron. It is a little stouter and less capillary than the preceding, with the extremities bent, and, as it were, crisped (frisées).

In the first edition of Lamarck, the author makes no reference to Lamouroux, though he uses a name which that naturalist had given him. He says, also, that it came from Australasia, and was in his cabinet. Mr. M'Gillivray was of opinion that my *Serialaria australis* was the same species. I have copied Lamouroux's figure (pl. 4, fig. 1, edit. of 1816), from which it will be seen that his species is entirely different, not only because the cells are in a single series, but because the setaceous appendages are of quite a distinct form. Lamouroux's true *S. cornuta* has, I believe, been lately found at Port Jackson, where it is very common. It is fairly represented by his figures, of which a copy is here given.

267. *A. unilateralis.*—Branches bent inwardly, groups of cells very close, almost touching, and placed on the same side.

A. u., ramis arcuatis, conglomerationibus cellularum approximatis, unilateralibusque. Mediterranean Sea. Ded. Balbis.

Serialaria unilateralis.—Lam. loc. cit.; also Lamouroux, Esposit. Meth., p. 10, pl. 66, fig. 1 and 2; Ency. Meth. Zooph., p. 43. M. Deshayes adds (second edit. Lamarck, p. 170)—Inhabits the Mediterranean coast. M. Blainville regards this species as a true Plumularia (Manuel, p. 476). But this opinion appears to me altogether inadmissible. This species is not mentioned by Lamarck.

268. *A. alternata.*—Lamouroux.—Very much branched, groups of cells, very long alternate on the branches, and very close; cellules numerous, of equal size. A. a. *ramosissima, conglomerationibus cellularum alternatis, approximatissimis, cellulis numerosis, subæqualibus.* American Seas. The Antilles, Deshayes.

Expos. Meth., p. 10, pl. 65, figs. 18 and 19; Encyclop., p. 44; *Serialaria alternata,* Deshayes, Lam. loc. cit.

269. *A. convoluta.*—Lamouroux Poly. Flex. p. 160.—All the cells united, and forming one single, exsert group, twisted in a spiral manner round the stems and branches.

A. c. *cellulis coalescentibus; conglomeratione cellularum eminente, contorta;* Australasian seas.—Encycl., p. 44.

Serialaria crispa.—Lamarck, first edit., n. 4, p. 131, Vol. 2., M. Edw. and Desh; Lamarck, second edit. *S. convoluta.*—Blainville, op. cit., p. 476. They add seas of New Holland. Peron and Lesueur.—My collection (Lamarck's) a little smaller than the preceding (*A. spiralis,* Lamouroux). It is ramose, paniculate; its spiral is less regular, wider, plicate, almost fringed, and sometimes interrupted.

270. *A. spiralis.*—Lamouroux.—Ramose, dichotomous; cells forming a single group, spirally twisted round the axis, and adhering by the internal pores of the cells. *A. s. ramosa dichotoma, cellulis coalescentibus, conglomeratione spirali, facie interne axi adherente.* Australasian seas. Peron and Lesueur.

Serialaria convoluta, Lamarck, first edit., Vol. 2, n. 3, p. 130; second edit. (Milne Edw. and Desh.), Vol. 2, p. 171; Lamouroux Expos. Meth., p. 10, pl. 65, figs. 16, 17; Encyclop., p. 44; *Serial. conv.*, Schweigger, op. cit., p. 476; *Serialaria spiralis,* Blainville, op. cit., p. 476. Lamarck adds:—"My collection, stem from 15 to 18 inches long, sustaining alternate branches, which are simple filiform, surrounded by a clasping, spiral, continuous series of coherent cells."

I have reproduced the figure given by Lamouroux. It has a slight resemblance to my *A. bicornis (Serialaria spiralis* * *nobis*), but the cells are unarmed, and attached by their inner wall. I have not seen this species; but as there seem to be so many in Australia, and as a good number of those enumerated as gathered by Peron were found in West Australia, or near the Bight, probably this will still be found.

The following species not described by Lamouroux in his first work (though mentioned in his *Exposition Methodique),* are described by Messrs. Milne Edwards and Deshayes in the second edition of Lamarck.

A. acervata.—Lamouroux.—*S. pumila, parum ramosa, subdichotoma, ramis capillaceis, tenuisissimis, cellulis subdisjunctis in massam distinctam distanterque congregatis. Serialaria acervata,* M. Ed. and Desh. Lamk., op. cit., p. 170; Blainv., op. cit., p. 476. In form the groups of cells are distant a millimetre from one another. They are composed of nearly 20 cells, heaped without order around the subdichotomous stems, which are not much branched, and isolated during the greater part of their length.

A. precatoria.—Lamouroux.—*S. cæspitosa, ramosissima;*

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* Proceed. Roy. Soc., N.S.W., 1877, p. 84.

ramis elongatis, ramosis, tenuissimis, conglomerationibus cellularum ovalibus, distinctis, precatoriis, cellulis subsejunctis, aliquoties unilateralibus.

Lamx. Encyclop., p. 45; *Serialaria, p.*, Blainv. op. cit. p. 476. Found on the coast of Brittany. Desh. and M. Ed., loc. cit.

A. semi-convoluta.—Lamouroux.—Encyclop., p. 44. *A. ramosa, capillacea, ramis sparsis conglomerationibus cellularum longissimis, distinctis convolutis vel semi-convolutis.*

Serialaria, semi-convoluta, M. Ed. and Desh. loc. cit. They add—Hab. Medit. Sea. This species establishes the passage between two species of *Serialaria.* The stems and the ramifications are filiform or capillary; the groups of cells are very distinct although near, and the cells themselves are all the same length.

A. australis, nobis, Proc. Roy. Soc., N.S.W., loc. cit. Polyzoary, with the internodes completely occupied by 7 to 10 tubular cells, adnate to one another perpendicular to the frond, curved and lengthening towards the end of the series. Internodes serial or giving off two others at right angles. Two long ligulate processes proceeding apparently from the terminal cell-mouth of each internode, and about twice their length. Mouth of the cell somewhat crescentic, with a thickened margin.

A seaweed, Guichen Bay, S.A., of a light brown colour, and very like a mass of aphides, branches corrugated, and constricted at the internodes. Some of the cells have a conical cap. Nearly all the cells in a double series. *Serialaria australis,* nobis, loc. cit.

Amathia Bicornis, nobis. Op. cit. p. 84, as *Serialaria spiralis.* P. dichotomously branched with clusters of cells in series of 20 to 24, disposed spirally round the axis of the branches. Cells attached by their bases only, nearly four times as long as wide, each provided with two divergent hollow spirals half as long as the cell,

Darker in colour than the preceding—*Amathia Woodsii,* Goldstein, Proc. Micr. Soc. Vic., 1879.

It would seem from the confusion between the works of Lamouroux and Lamarck, and the identity of some of their names, as if there had been some misunderstanding between them. It is, however, pretty certain that Lamarck does not acknowledge Lamouroux's assistance, or admit that he was using his names. This is all the more strange, if we remem-

ber that at the same time Lamarck was in the height of his fame, and in the decline of life (he was 72), while Lamouroux (then 37) was struggling into notice as a professor in a remote provincial town. It seems somewhat unaccountable to me that so many zoologists in succession should have admitted Lamarck's names without a question. This arose from the dates of the two works being the same, and probably Lamarck's being published earlier in the year, since he was careful to put the date of March on his second volume. Naturalists forgot, however, that Lamouroux's *genera* were published four years previously in the *Bulletin*, to which he refers. It is true that Lamarck's definition is much more precise and definite; but yet he misunderstood these organisms, as he placed them next to *Plumularia*. His generic definition is as follows:—*Polyparium phytoideum, corneum, surculis gracilibus, fistulosis, ramosis, calyciferis, calyces cylindracei, prominuli, paralleli, seriatim cohærentes, in massas distinctas vel in spiram continuam dispositi.*

The remarks of Mons. Edwards in the second edition, showing how well he understood these organisms, are as follow:—"These polypi differ very much from the *Sertularieæ Campanulariæ* and *Plumulariæ*, and appear to me to have the same kind of organisation as *Cellularia* and *Flustra*. The tentacles are furnished on each side with a linear series of vibratile cilia, and the mouth opens upon an alimentary canal, which is bent on itself, and curves round so as to terminate on the external side of the orifice which bears the tentacles. *Serialaria* consequently belong to the *Bryozoa*."—*Op. cit.*, p. 169.*

Before concluding this paper I may as well give a general outline of the progress of the knowledge of the Polyzoa from the time of Lamarck. He was followed in the matter of classification by Dr. Auguste F. Schweigger in 1820 *(Handbuch der Naturgeschichte, Leipzig)*, who made important changes, but not for the best. He unfortunately perished during his zoological explorations in Sicily. The *Manual of Natural History* of Goldfuss appeared about the same time; but with few exceptions this was not successful as an attempt at systematising. Lamouroux's second work, to which reference has often been made,

*It must not be thought that I wish unduly to exalt Lamouroux. As a systematist he was a failure. See *Blainville Manuel d'Acteonologie*, p. 54; Johnston's *Brit. Zooph.*, second edit., Vol. 1, p. 448.

followed in 1821. Latreille made another attempt in 1825 in his *Families of the Animal Kingdom.* It is said of this that he only borrowed from Messrs. Cuvier, Lamarck, and Lamouroux. Gaillon and Bory St. Vincent followed, and then Dr. Fleming was the only British naturalist who tried his hand at the arrangement of Zoophytes;* but though he knew his subject well, and made some valuable discoveries, yet his method, as well as that of Oken and Van der Hoven, have long been forgotten. I will only say of the latter that I know of no work that contains such marks of extensive reading, or where there are such copious references to the bibliography of the subject, as in his essay on the art of classifying.†

At the same period Prof. Grant (1827) made important researches into the anatomy of Flustræ, which were followed by those of Milne Edwards in 1828. About this time Mr. J. V. Thompson proposed the establishment of a separate class, which he named POLYZOA. Prof. Ehrenberg subsequently (in 1834) suggested the name *Bryozoa.* In 1836 Dr. Johnston, the author of *British Zoophytes,* proposed that the primary sections of zoophytes should be named *radiated* and molluscan.‡ The latter were embraced in one order. The *M. Ascidioida,* a name intended to point out its immediate affinity with the *mollusca tunicata* and the radiated zoophytes, were divided into three orders, the same as those of Milne Edwards, but designated the *Hydroida, Asteroida,* and *Helianthoida,* names which have been adopted by naturalists in general. In 1840 Mr. J. Hogg proposed a different classification of the zoophytes, founded on the structural peculiarities of the tentacula.§ In 1843 Prof. Owen, in his *Lectures,* proposed to divide the radiated zoophytes into two classes—the hydrozoa and anthozoa—which latter was made to include the orders *Asteroida* and *Helianthioida.*

I do no more than refer my readers to the whole series of the *Annals of Natural History* for the successive labours of Messrs. Alder, Allman, Albany, Hancock, Wyville Thompson, Busk, and others. The *Philosophical Transactions* contain Dr. Farr's valuable papers. The names of Dr. Bowerbank, Sir J. G. Dalzell, Sars (Fauna Novegs), Van

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* *History of British Animals,* Edinburgh, 1828.
† Van der Hoeven's *Zoology,* translated by Dr. Clark, 2 vols, London, 1856.
‡ *Magaz. Zool. and Bot.,* Vol. 1, p. 447.
§ *Ann. Nat. Hist.,* Vol. 4, p. 366.

Beneden, and Peach, can only be mentioned, as their labours must be familiar to all who are interested in the subject.

One of the most important steps ever made to a complete arrangement of the Polyzoa was that published by Dr. Busk in the *English Cyclopædia,* conducted by C. Knight,* and published in 1856. The same author had already published, in 1852, the first part of a catalogue of the Marine Polyzoa contained in the collection of the British Museum. Between the publication of the first part and the third in 1875, an immense number not only of *genera,* but species, have been created by various authors. Even to name a few, such as Landsborough, Gosse, Hincks, Norman, D'Orbigny, Hassal, Couch, Smitt, Gray, Lister, Macgillivray, Hyndman, Heller, Fritsch, Forbes, Meneghini, Kirchenpaur, will show how the subject has grown. In the meantime warning notes are reaching us from every side that the present system of classification is founded on very unstable ground. For the great divisions probably there would be but little change, if any, suggested, but for the smaller divisions, and especially the *genera,* as the animals are better known and their mode of grouping or building their frail tenements understood, some of the generic distinctions are fading away. The master-mind that will grasp the whole is yet to come, and we have only to fear now that amid the multitude of workers it will be very difficult to arrive at some common bond of agreement which all naturalists will accept. It appears, however, that there is a general disposition to accept a system of classification such as Professor Lankester has put forth. Thus Polyzoa are divided into the sub-classes :—1, Holobranchia ; 2, Pterobranchia. The first into groups—Ectoprocta, which is divided into the orders Phylactolæma and Gymnolæma, &c., &c. There is at the same time evidence of various schools which will represent the views of Lankester, Hæckel, or Huxley, as the case may be.†

I must not close this article without referring to the persistent labours of the Rev. Thos. Hincks, F.R.S. He has given himself so entirely and successfully to the study of the Polyzoa that Australian species have already received much elucidation from him. At the same time, his descriptions are so full and satisfactory, and his drawings so

* *Natural Hist.*, Vol. 4, p. 415.

† See "On Germinal Layers," &c., *Ann. Nat. Hist.*, May, 1873 ; and "On Embryology and Classification," *Quart. Jour. Micros. Sc.*, Oct., 1879, p. 393.

accurate and artistic, that his work forms a new area in this study of these organisms. They will no longer be so beset with difficulty as they have hitherto been if his example is followed.*

EXPLANATION OF PLATE.

FIG. 1.—*Amathia lendigera.*—Linn, after Ellis.

FIG. 2.—Ditto, cells much magnified, after Busk; a. a., armature of mouth.

FIG. 3.—*Amathia cornuta.*—Lamx., copied from the fig. in Polypiers flexibles, pl. 4, fig. 1.

FIG. 4.—*Amathia spiralis.*—Lamx., from fig. op. cit., pl. 4, fig. 2.

FIG. 5.—Same, nat. size; from the same.

FIG. 6.—*Amathia tortuosa.*—Tenison-Woods.

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* See especially "Notes on the *Genus Retepora*," *Ann. Nat. Hist.*, May, 1878, p. 353; on "Polyzoa from Iceland and Labrador," Jan., 1877, p. 97.

APPENDIX.

LIST OF AUTHORS WHO HAVE WRITTEN DIRECTLY OR INDIRECTLY ON POLYZOA.

The following list, I venture to hope, will be of use in Australia, and worthy of a place in the transactions of the Royal Society of Victoria. It is the result of notes made during many years' study of natural history in Australia. I have so often felt the want of some reference to works, when no more than the author's name was given in scientific writings, that I cannot doubt its usefulness to students. It may help, also, as a guide to researches in our public libraries, and may be the means of introducing many of the works here named, not only to students, but to the colonies where they are not yet to be found :—

Adams, John.—Descrip. of some Marine Animals Found on the Coast of Wales ; Trans. Lin. Soc., Vol. 5, p. 7. London, 1798.

Aldrovandus, Ulysses.—Museum in Libros, 4 distrib. Bologna, 1648. There is a copy of this work in the Sydney Museum.

Alder, A.—M. Nat. Hist., 1856, pp. 353, 439.

Allman, G. J.—Proc. R. Irish Acad., 1843 ; Do., 1850 ; Ann. Nat. Hist., Vol. 13, 1844, p. 328 ; Rep. Brit. Assoc., 1849, p. 71 ; L'Institut., Vol. 18, No. 837, 1850, p. 19 ; Brit. Ass. Rep., 1850, p. 305 ; a Monograph of the Fresh-water Polyzoa, including all known species, printed for the Roy. Society, London, fol, with 11 plates ; Homology of Polyzoa ; Transact. Roy. Irish Academy, Vol. 22, p. 3, 1852 ; p. 275, Vol. 5 ; 1850, p. 237.

Argenville D', A. J.—L'Historie Naturelle eclaircie dans deux de ses Parties Principales, la Lithologie et la Conchyliologie, &c. Paris, 1752, 4to, plates.

Archiac D'.—In Memoires of the Geol. Soc. of France Generally.

Aristotle.—Historia Animalium. Bohn's edit. and translation.

Audouin, Victor.—Ann. des Sc. Nat. Generally.

Audouin, Victor.—Recherches pour servir a l'Hist. Nat. de France ; 2 vols, 8vo, 1832-34.

Baker, Henry.—A Natural History of the Polype. Lond., 1743, 8vo, plates.

Barrel, A. R. P.—Jac. Icones Plantarum per. Galliam Hispan. et Ital. obs. op. Posthumum, by A. de Jussieu. Paris, 1714, 4to, plates.

Barrow, J.—Travels in S. Africa in 1797 and 1798; 8vo. London.

Bartholini, Stephanus.—Acta Medica and Phil. Hafniensia. Copenhagen, 1672-79, 4to, plates.

Baster, J.—Observationes de Corallinis Philosoph. Transac.; Vol. 41, Lond; and Opuscula Subseciva obs. Miscellaneas de Animalculis et Plantis Marinis. Harlem, 1759-65, 4to, plates.

Bauhini, Caspar.—Pinax. Theatri. Bolanici sive Index, Theophrastii, Dioscoridii, Plini, &c. Bâle, 1623, 4to.

Bauhini, Caspar.—Historia Plantarum. Embrun, 1650, fol, plates.

Beraud, J. J.—Mem. sur. le Corail. Acad. de Marseille Mem., Vol. 17, 1787.

Bernard.—Dictionnaire Universel Les Fossiles, 1763, 4to.

Bertolini, Ant.—Rar. Ital. plant. Accedit, Specimen Zoophytorum. Pisa, 1810, 8vo.

Besleri, M.—Rup. Gazophylacium Rerum Naturalium ex Regno Veget. Animali et Minerali. Nuremberg, 1642, et Leipzic, 1733, fol, plates.

Beudant, M.—Mein. sur. Mollusques; Radiares et Zoophytes, 1810; Annales du Mus d'Hist. Nat., Vol. 16, p. 71.

Boccone, Paul.—Recherches d'Hist. Nat. touchant le Corail. Paris, 1670; Amsterdam, 1674, plates.

*Boccone, Paul.—Museo di Fiscia e di Esperienze Variato et Decorato di Osserv. Nat., &c. Venice, 1677, 4to, plates.

Boerhaave, Hermann.—Index alter Plantarum Lugduno-Batavi; Leyden, 1720, 4to. Index Plantarum in horto Leidense; Leyden, 1720, 4to.

Bohadsch, J. Bapt.—De Quibusdam Animalibus Marinis. Dresden, 1761, 4to, plates.

† Bonani, Phil.—Museum Kircherianum. Rome, 1709, 4to, plates.

Borlase, Rev. William, F.R.S.—Natural History of Cornwall. Oxford, 1758, fol, plates.

Borowski, G. H.—Natural History. Berlin, 1780-89, 10 vols, 8vo, 450 coloured plates.

Bory, St. Vincent.—Essais sur les iles Fortunees; Paris, 1802, 4to, plates. Voyage dans les isles d'Afrique; Paris, 1804, 8vo, plates.

Bose, J. A. G.—Hist. des Vers, Buffon, edit. de Deterville. Paris, 1802, 18 plates.

Bouvier.—Analyse de la Coralline; Ann de Chimie, Vol. 8, p. 308.

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* Lamouroux says of this book that the plates are badly engraved and almost useless.

† This work first appeared in 1684, and another edition, by Contuccio, in 1765, fol., 45 plates.

Boys, Henry, F.L.S.—Account of Flustra Arenosa and other Marine Productions, trans. Linn. Soc., Vol. 5, p. 230.

Brady.—Philos, trans, Vol. 49, p. 249, plates.

Breyn, Jac.—Prodromus Rariorum Plantarum. Dantzic, 1739, 4to, plates. This is another edition by Philip Breyn of the works of his father published in 1678-89.

Bromel, V.—Mineralogia and Lithographia. Stockholm, 1740, 8vo, plates.

Brown, Patrick.—Civil and Nat. Hist. of Jamaica. London, 1756, fol, plates.

Brugiere.—Histoire Naturelle des Vers Encyclopedie Methodique. Paris, 1789, 4to.

Brugiere.—Tableaux Encyclopedique des trois Regnes de la nature ou sout Figurés les Vers. Paris, 1791, 4to, plates.

Busk, Geo., F.R.S.—Catalogue of Polyzoa, Part 1, 1852; Part 2, 1854; Part 3, 1874. London; portion of Brit. Mus. Catalogue. Polyzoa of the Crag; Paleontographical Society's Memoirs, 1857; Quart. Jour. Geological Society, 1860, 16, p. 261; Quart. Jour. Microscop. Soc., Vol. 7; Polyzoa of Natal; Rep. Brit. Ass., 1850, p. 118.

Buttner, Sigism.—Coralliographia. Leipzic, 1714, 4to, plates.

Blainville de Manuel d'Actinologie; Paris, 1834, 8vo, plates. Dictionnaire des Sciences Nat., Vol 60, 1830.

Calceolarii, Francis.—Museum Descrip. a A. Chiocco et A. Ben. Cerutto. Verona, 1622, folio, with numerous excellent plates.

Catesby, Mark.—Nat. Hist. Carolina, &c. London, 1731, fol, plates; a German edition, Luxemberg, 1750.

Calleville, J. B. Calleau.—Tableau de la Mer. Baltique.

Cavolini, Filipo.—Memorie per Servire alla Storia de Polypi Marini. Naples, 1785, 4to, with numerous exact plates.

Chiaje, Delle.—Anim. s. Vert. Naples, 1829; alt. scrip., 1841.

Chabræi, Dominici.—Stirpium Icones et Sciagraphia. Geneva, 1766, fol, plates, which are the same as those in Bauhini's work.

Clusius, Charles.—Atrebatis, &c., Rar. Plant. Historia; Antwerp, 1601, fol, plates; Exoticorum Animalium, lib. 10, cum obser., P. Bellonii, obs. Antwerp, 1605, fol, plates.

Couch, R. Q.—Ann. Nat. Hist., Vol. 15, p. 161; An Essay on the Zoophytes of Cornwall; Ninth Ann. Rep. Cornw. Polytech. Soc., 1841, p. 27, 1841, 8vo.

Coste.—Polyp. Fluviatile; Comp. Rendu Acad. Sciences, Vol. 12, 1841, p. 724; and Edinb. New Phil. Journ., Vol. 32, 1842, p. 70.

Carter.—Ann. Nat. Hist., 1859, p. 331.

Cuvier, G.—Anatomie Comparée. Paris, 1800, 8vo.

Dana, James D.—Geog. Dist. of Zooph.; Edin. New Phil. Jour., Vol. 43, 1847, p. 41; Fror. Nat. 3. Reibe, Vol. 3, 1847, p. 21; Ann. Nat. Hist., 1847, p. 98.

Denon, Vivant.—Travels in Egypt. Paris, 1803, 4to, plates.

Defrance.—Tabl. des. Fossiles. Paris, 8vo, 1824.

Desmarest and Lesueur.—Mem. on some Fossil Cellepores; Bulletin Philomatique. Paris, 1814, 4to, plates.

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Dicquemare.—Jour. de Physique, Vol. 28, 1786, p. 429.

Dictionnaire des Sciences Medicales par une Societé de Medicins et de Chirurgiens. Paris, 1812, 8vo, plates.

Donati, Vitalian.—Saggio d. Storia; Nat. Marina dell Adriatico. Venice, 1750, 4to, plates.

Dumeril, A. M. C.—Zoologie Analytique. Paris, 1806, 8vo, plates; and Traite Elem. d'Hist. Nat., 1807, 8vo, plates.

Durand, J. B. L.—Voyage to Senegal. Paris, 1807, 8vo, Vol. 1, p. 314.

Dumortier, B. C.—On the Anatomy and Phys. of Polypes; Bullet. de l' Acad. of Brussels, Vol. 2, 1835, p. 422; Fror. Nat., Vol. 49, No. 1069, 1836, p. 193; 1070, p. 211; also, Nouv. Mem. d'Acad. de Brux., Vol. 16, 1843; l'Institut, 4, 161, 1836, p. 183; also, Ausz in Isis, 1837, p. 770.

Edwards, G.—Nat. History of Birds and Gleanings of Nat Hist. Lond., 1745-58 (translated into French), 4to, plates.

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Elien, C.—De Nat. Anim., libri 17 (in Greek and Latin, with notes of Abraham Gronow); Lond., 1644, 4to; Second edit. of Schneder, 1784, 8vo.

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Ettmuller, Michael.—Coralliorum Tincturæ Examen. Leipsic, 1665, 4to.

Fabricius, O.—Fauna Grœnlandica, 8vo. Copenhagen, 1780.

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Fleming, Dr.—Hist. Brit. Animals, 8vo. Edinburgh, 1828.

Forskal, Peter.—Icones Rerum Naturalium. Copenhagen, 4to, plates.

Fortis, Abbé.—Voyage en Dalmatie. Berne, 8vo, plates, 1778, Vol. 1, pp. 217, 218, 225, 236; Vol. 2, p. 244.

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GARDUCIERES, DE, Theoph.—On the Virtues and Effects of Coral. London, 8vo, 1676.

GALEOTTI.—Mem. del' Acad. de Bruxelles, 1837, &c.

GERARD, John.—Herbal; or, Gen. Hist. of Plants. London, 1633, fol, plates.

GERVAIS, P.—This author has written very extensively on f.w. Polyzoa since 1836. His writings can be found principally in Comp. Rend. Acad. Sc., Vol. 3, 1836, p. 796; l'Institute, No. 190, p. 433; No. 258, p. 398; No. 311, p. 435; No. 267, p. 42; also, Soc. Philom., 1838, p. 129, besides many other papers, essays, &c.

GESNER, C.—De Rerum Fossilium. Zurich, 1565, 8vo, plates.

GINANI, Count G.—Istoria d. Piante Marini. Venice, 1755, fol, plates.

GMELIN, Jo. Frid.—Systema Nat. Car. Linne, edit. 13. Leipsic, 1788.

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HASSELQUIST.—Travels in the Levant, translated into many languages, *vide* Paris edit., 8vo, 1769, Vol. 1, p. 255.

HASSAL, A. H.—Catal. of Irish Zoophytes; Ann. Nat. Hist., Vol. 6, 1841, p. 166; Vol. 7, 1841, pp. 276, 363, 483; and other papers.

HATCHETT, C.—Phil. Trans., 1800, p. 327.

HAGENOW, F. V.—Bryoz, Maestrichter Kreidebildung. Cassel, 1851, 12 plates.

HAIME, J.—Descrip. Bryozoaires Fossiles de la Formation Jurassic, 6 plates; Mem. Soc. Geologique de France, second ser., Vol. 1, 1854, p. 157.

HANCOCK, A.—On Anatomy f.w. Bryozoa; Ann. Nat. His., Vol. 5, 1850, p. 173.

HINCKS, Rev. Thos.—Rep. Brit. Ass., 1852, p. 75; Ann. Nat. Hist., from 1870, passim. This writer has described many Australian species.

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HUMBOLDT.—Vues des Cordilleras; Paris, 1816, 8vo, plates; Vol. 2, p. 218. Voyages; Paris, 1816, 8vo.

HUGHES, G.—Nat. Hist. Barbadoes. Lond. 1750, 8vo, plates.

HUXLEY, T. H.—On Cheilostomatous Polyzoa; Quart. Jour. Micros. Soc., Vol. 4, 1856, 191. See generally the writings of this author, too numerous to specify.

IMPERATO, F.—Historia Naturale. Venice, 1672, fol, plates.

ISIDORE, St. (a Spanish bishop).—De Plantis. Mantua, 1559, fol.

JOHNSON, Dr.—Brit. Zoophytes, second edit., 2 vols., 8vo, plates; London, 1847. This work may be carefully perused, and will afford an immense amount of information, biographical as well as zoological, all written in a charming way. He is the author of many papers, &c., too numerous to specify.

JONES, Th. Rymer.—Art Polypifera in Todd's Cycloped. of Anat. and Physiol.

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Jour. Geological Soc., London, passim.

Jour. Linn. Soc., passim.

Jour. Geograph. Society.

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KROHN, A.—Organe bei den. Bryozoen; Fror. N. Nat.,Vol. 25, No. 533, 1843, p. 70.

KÖLLIKER.—Randkorper d. Quallen; Polypen u Strahlthiere; Fror. N. Nat., V. 25, 534, 1843, p. 81.

KNORR, G. W.—Deliciæ Nat. Selectæ. Nuremberg, 1754-67, fol, plates.

KRIEGEL, A.—Dissert de Spongiarum. Leipzic, 1734, 4to.

LABILLADIERE.—Voyage a la Recherche de Lapeyrouse, 8vo, 2 vols., with atlas; Paris, 1799, 44 plates, of which 14 are botanical; also, Sertum. Austro-Caledoneum; Paris, 4to, 84 plates, 1824-25.

LAMARCK.—Phil. Zoologique; Paris, 1801, 8vo. Systeme d'Animaux, S. Vert.; Paris, 1801. Cours de Zoologie; Paris, 1812. Sur les Polypiers Empates; Ann. du Mus., Vol. 20, 1813; Sur les Polypiers Corticiferes; Mem. du Mus., Vol. 1, 1815, pp. 401, 467; Vol. 2, 1815, pp. 76, 157, 227.

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LESEBLE, O.—Hist. Gen. Bryozoaires. Tours, 1859, 8vo.

LEIBOLD, F.—Beiträge zur Naturgeschechte der Polypen. Dresden, 1847.

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LEIDY, Jos.—On some American f.w. Polyzoa; Proc. Acad. Nat. Sc. Philadelphia, Vol. 5, 1851, p. 320.

LISTER, Jos. T.—Structure of Polypi, &c.; Entomol. Mag., Vol. 3, 1836, p. 172.

LINNE, Car.—Hortus Cliffortianus; Amsterdam, 1737, fol, plates. Corallia Balthica, 1745, 4to, plates. Mus. Tessianum; Stockholm, 1753, fol, plates—pl. 10, 11, and 12 have figures of Polyzoa. Fauna Suecica, ed. 11; Stockholm, 1761, 8vo. System Nat., 10 to 12 edit.

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LIEBKNECHT.—Hessiæ Subterraneœ Specimen. Hesse Cassel, 1750, 4to, plates.

LUDWIG, C. G.—De Veg. Plant Marinarum. Leipzic, 1736, 4to, 1 plate.

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MACDONALD, J. D.—Proc. Roy. Soc.; Lond., Vol. 8, 1857, p. 383. Ann. Nat. Hist., Vol. 19, 1857, p. 390.

MACLAREN, C.—On Coral Islands; Edinb. Phil. Jour., 34, 1843, p. 33; Remarks of C. Darwin on the same, p. 47.

MANZONI, Bryoz Foss. Ital.—Sitzungsb d. Kais Akad d. Wissensch, Vol. 61, 1 Abth., 1870.

MACGILLIVRAY, P. H.—Cheilostomatous Polyzoa of Victoria and other parts of Australia; Trans. Roy. Soc. Victoria, 1860, p. 168, plate 3.

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MARSDEN, Will.—Hist. of Sumatra. London, 1784, 4to, plates.

MARSILLI, Count De.—Hist. Physique de la Mer. Amsterdam, 1725, fol, plates.

MAZZOULI, F. M.—Diss de Corall. Mem. di diversi. Valent, Vol. 1, 1743, p. 123.

MEYEN, F. J. F.—Natur. der Polypen in Isis, 1828, p. 1225.

MELTZER, C. D.—De Coralliis Dissertatio. Koenigsberg, 1728, 4to.

MERRET, C.—Pinax Rerum Nat. Brit. London, 1667, 8vo.

MILBERT.—Voyage a l'Ile de France. Paris, 1812, Vol. 1, p. 226; Vol. 2, pp. 26, 34, 301.

MOLL, J. P. C.—Eschara ex Zoophytorum, &c. Vienna, 1803, 4to, plates.

MORANDI, J. B.—Historia Botanica. Milan, 1744, fol, plates.

MORRIS, R.—Plantarum Hist. Universalis. Oxford, 1715.

Muller, D. Fred.—Zoologicæ Danicæ Prod. Copenhagen, 1776, 8vo; also 1788 to 1806, fol, plates.

Muller, John.—Zoophyten, &c.; Dessen Archiv. f. Anat. und Phys., 1858, p. 90.

Milne, Edwards.—Hist. Nat. de Cor., 3 vols. Paris, 1854. Besides a large number of Memoires and the revision of the Polyzoa in Deshayes, second edit. of Lamarck.

Memoires de la Soc. Nat. de Paris.

M'Coy, F.—Various Memoirs and Papers on Palœontology, &c., too numerous to specify.

Museum Richterianum. Leipsic, 1743, fol, plates.

Michelin.—Iconographie Zoophytologique Descrip. des Polypiers Fossiles de France, &c., 5 livrasons, 1841-42, Paris, plates.

Molina.—Hist. Nat. d. Chili, 8vo, 1789, Paris.

Morren, C.—Descrip. Coral Foss. in Belgio Repert, 1828.

Nardo, G. D.—Nuovo Classif. dei Zoofiti; Atti della Riun. Scienz; Ital, 1843, p. 43; Isis, 1845, p. 635. Also, Nuov. Ann. delle Scienz Nat; Bologna, 2 ser., Vol. 3, 1845, p. 104; Vol. 2, 1844, p. 460. Published separately Vicenza, 1845.

Nieremberg, J. E.—Hist. Naturæ. Antwerp, 1835, fol.

Nordmann, Av.—Susswasser Polypen von Paris, &c.; Bull. Sc. Acad., St. Petersbourg, Vol. 8, 1841, p. 353.

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I have omitted the name of J. E. Gray from this list, whose writings on Nat. Hist. are so voluminous, and who, amongst other departments, wrote on the Polyzoa, especially in Dieffenbachs, N. Zealand. Appendix.

There are few of my readers who will not be able to suggest additions to this list in the writers of the last ten years, especially in the *Annales Sciences Naturelles*, the *Annals of Natural History*, and the *American Journal of Science and Art*, the *Geological Magazine*, &c. I must add, also, that I did not propose to refer to any but new observations, so I make no reference to *Nature*, the *Pop. Science Review*, and similar serials. I need scarcely remark that a large number of the works quoted have not been seen by me, though I have been fortunate in seeing an unusual number of the older ones. I can never say enough in praise of the value and use of the figures and descriptions of some old and almost forgotten authors; and I have seen new reason every day for verifying every authority, no matter how trustworthy the author. It is related of the celebrated patriotic scholar, Dr. Martin Routh, that when asked for some important and valuable principle as a result of all his literary experience, his reply was, "Verify your references." A more important principle in scientific literature can scarcely be imagined. Let me hope that my imperfect labour in the foregoing list may help the student in this way.

Art. V.—*Notes on the Customs of Mota, Banks Islands.*

By the Rev. R. H. Codrington, M.A., Fellow of Wadham Coll., Oxon.

With Remarks by the Rev. Lorimer Fison, Fiji.

[Communicated 10th July, 1879.]

[Some years ago it was my great good fortune to be concerned in a matter which led to an exchange of letters between the Rev. R. H. Codrington, M.A., of the Melanesian Mission, and myself. The correspondence thus begun has been maintained, chiefly with regard to the customs and the languages of the tribes within our knowledge. The facts communicated to me by Mr. Codrington are so valuable, and his comments upon them are so interesting, that I ventured to urge him strongly to publish them. In reply, he was kind enough to give me permission to make any use of them I pleased, "bearing always in mind that they are only *notes*." It seems to me, that I cannot make a better use of them than by laying them before the Royal Society of Victoria in his own words, together with such additional remarks as may be suggested by my knowledge of the customs of other tribes. The facts will be thereby presented all the sooner to those who are interested in the study of anthropology, and will cause them to look eagerly for the publication of a work on Melanesian customs and languages, which we may hope to welcome, sooner or later, from Mr. Codrington's pen.

My own remarks are enclosed in brackets, and signed with my initials, in order to distinguish them from his.—L. F.]

1. System of Relationship.

The Banks Islands people, though speaking dialects mutually unintelligible, have throughout the same two families, not properly tribes, called in Mota veve—mother. The members of these two veve are mixed indiscriminately in the villages, and have their property equally mixed. The division exists only for the purpose of distinguishing families. There is no common name to the veve. It is said of people belonging to the same veve, "The mother is one;" of those belonging to different veve, "The mother is different." All of one veve are said to be "sogoi" to one another. These divisions are called veve at Mota only; but any Banks islander knows, or can find out, his sogoi on any island. The veve are exogamous, and descent follows the mother.

To a limited extent, within the veve there are certain families, or family connections, which take a name from a particular place. This can scarcely be called a family name—*e.g.*, at Mota a certain family are "*Talo Sepere*," of Sepere, a place in the island of Vanua Lava; and the sons—who are not of the father's veve, because descent is through the mother—will try to marry into the Sepere set again.

Those of the same veve are said to be "on one side of the house;" those of the other veve are said to be on "the other side of the house" (tavala ima). A man must marry a tavala ima. His wife does not come over to his side of the house, but is said to be "at the door." Her children belong to her side of the house, not to his. Hence a man's own children are not "sogoi" to him. His nearest relations are his sister's children, for these are of his veve, and continue his family.

["The other side of the house," see *Supwe*, No. 29 (Gamal). I omit Mr. Codrington's interesting remarks on the terms of kinship and affinity. These require a special study.

The Mota veve are the two exogamous intermarrying divisions, with descent through females, which are found so widely prevalent elsewhere. They are frequently subdivided into four, and these again into smaller divisions; but the memory of the primary divisions is generally kept up, either by actual nomenclature, or by tradition. The badge, or symbol, of a division is generally, though not necessarily, an animal. This is, in fact, the American Indian totem (Dodeim). There is a mysterious relationship between the totem and those who bear it as their "crest." A man does not willingly kill or eat his totem. I have found divisions similar to the Mota veve in the island of Vanua Levu, Fiji. Probably all the Fijian tribes had them formerly.

The Banks islanders seem to have advanced far beyond the old commune, which was undoubtedly represented by the two veve.

Descent is still uterine in some parts of Fiji, as in Mota. Most of the tribes, however, have advanced to agnatic descent. A community is divided into a number of MATA NGGALI, each of which is descended from a common ancestor, whose temple stands in the "quarter" of the town belonging to his mataggali. From each of the sons of this ancestor a minor division, called a YAVUSA, is descended; and each yavūsa is divided into a number of vūvále —households. A vūvále may consist of a number of brothers with their families. All the mataggali of a community—and, indeed, it may be of several communities—trace their common descent to a still more distant ancestor, who is the Kalou Vu, God ancestor, of them all.—L. F.]

2. Land Tenure and Inheritance.

Land is held as the property of individuals—*i.e.*, when bought it is bought from individuals. But the people never buy or sell land among themselves. When the mission has bought land, the individuals who received payment have sold rather an interest in the land than a limited piece of property. A piece of land is the property of a certain well-known number of people who have inherited it, and they use it for gardens—*i.e.*, food plantations—as they like, there being plenty of room.

Property in trees is distinct. A man may have fruit trees, planted by himself or an ancestor, on land to which he has no claim. The property of the two veves is intermingled.

Inheritance.—Land descends to the relatives "on the same side of the house"—*i.e.*, to the sister's children. But the practice is that the sons redeem it with the personal pro-

perty—pigs, money, &c.—which descends to them. This practice has become so established that of late, perhaps from some admixture of European ideas also, a man insisted on his right to his father's fruit-trees without paying the usual redemption-money, and shot the legitimate heirs for interfering.

There is no right of primogeniture. Daughters inherit land if there are no sons.

Bequests.—A man will give directions before death as to his personal property—what one son is to have, and what another. He will also arrange as to what his sons are to give to redeem the real property from his heirs—*i.e.*, from his sister's children.

[In Fiji the tenure of land is distinctly tribal, and the title is vested in all the fullborn members of the tribe. The land is of three kinds—the yávu, or town lot; the nggēle, or arable land; and the veikau, or forest. The veikau is common to all the members of a community, but the yávu and the nggele are divided and sub-divided. Each owner, however, holds for the household to which he belongs, the household holds for the clan, the clan for the tribe, the tribe for the community, and the community for posterity. Each generation has the usufruct only, and cannot alienate the land. The chiefs have overridden this rule, but most unjustly.

The law of primogeniture exists in Fiji to the extent that the eldest son succeeds to the headship of the household rather than the younger. In some of the tribes the descendants of the elder brother are the elder brothers for ever.

Fruit trees are often held by persons who do not own the land, but there is a curious distinction here. The property in this case is rather in the fruit than in the tree, and is, therefore, not considered to be *in* the land. You may take the fruit, but you must not cut down the tree without the landowner's permission. A remarkable distinction was made by one of my Fijian informants:—"He who has a tree on another man's land may cut it down and take it away. His axe does not touch the soil. But he may not dig the tree up by the roots, for his digging-stick would turn up the soil."

Inheritance follows descent. Descent being uterine in Mota, the sister's son inherits. As a general rule, this is not so in Fiji, excepting among certain tribes who have uterine succession. But the tribes which have agnatic descent still bear strong marks of the older line. The sister's son is vasu to his maternal uncle, and can take extraordinary liberties with his property.

Daughters can scarcely be said to inherit land in Fiji. Land is given *with* them on their marriage, but it is not given *to* them. If they hold at all it is only as a means of transmitting the land to their children.

The Mota practice of "redemption of the inheritance" is very interesting. It is a step towards agnatic succession; and I think we need not look to the introduction of "European ideas" for the cause of the violent assertion of ownership in the fruit-trees mentioned by Mr. Codrington. Uterine descent works well enough among nomad hunters or herdsmen; but agricultural settlement is sure to be fatal to it sooner or later.

Bequests of personal property are made in Fiji as in Mota.—L. F.]

3. Marriage.

A match is arranged generally by the relatives, and a payment is made to the father, who will give up his daughter when it is thought desirable. There is no ceremony; but

sometimes a wedding-feast is made when the matter is settled, after which, if it be so arranged, the bride stays with her husband. When there is a feast the father of the bride will make a present to his son-in-law, but not equal to that which he has received. In case of divorce—which is at the will of either party—the father gives back what he received if he gets another sum from a fresh son-in-law. In case of widowhood, the widow is at the disposal of her deceased husband's relatives, unless her dower be returned.

[The Fijian custom is similar. See Williams's *Fiji and the Fijians*.—L.F.]

(*a.*) *Polygamy.*—The usual custom is for a man to have two wives. This seems to be looked upon as a sign of wealth. In Vanua Lava, men are said to have many wives.

(*b.*) *Polyandry* exists but rarely; never with young people; but mostly as a matter of convenience, as when two widowers live with one widow. She is wife to both, and any child she may have belongs to both. There are cases in which a husband connives at a connection between his wife and another man. This is not counted adultery, for it is an open transaction; and it is not polyandry, for the parties are not husband and wife. The practice is not thought respectable.

[Polygamy was common in Fiji, especially among the chiefs, and led to much political disturbance. When a chief's wives were of equal rank, their sons, also, were of equal rank, and were carefully brought up by their mothers to hate one another with a deadly hatred. There is a word in the language for this "brotherly hate." Hence polygamy has been the most fruitful cause of wars and murders in Fiji.

Our Government, since annexation, has been sorely but quite needlessly exercised on this subject, and has considered it necessary to pass an ordinance to legalise polygamous marriages which were contracted before a certain date, and were in force at that date. This was done with the avowed purpose of legitimatising the children of such marriages who were supposed to have been illegitimatised by their mothers having been put away when their fathers turned from heathenism. The fact of the case is that these children were not illegitimatised thereby. The son of a chief by a lady of rank was a chief in his own right, and nothing could make him either illegitimate or more legitimate. Divorce was very common, but it had not the slightest effect upon the children; nor did it bring the slightest dishonour upon the mother if she were properly dismissed. It was even considered decent for the wife to return to her friends after she had borne a few children, and this custom is of wide prevalence elsewhere. Not long ago the wife of a Fijian chief applied to one of our stipendiary magistrates for permission to leave her husband. She had no complaint to make against him, but she thought it high time that she went back to her own kinsfolk.

Polyandry.—I am inclined to disbelieve in polyandry altogether as a distinct institution. All the cases which have come under my notice, or of which I have read in books, including the Nair polyandry and the American Indian instance quoted by Sir John Lubbock in his *Origin of Civilisation* (p. 101, 2nd ed.), seem to me to be either cases of communism under difficulties, or survivals of communism. Polyandry is to be seen under our eyes here in

Fiji among the "imported labourers," but the women may admit those men only who might lawfully approach them in their own islands. Not long ago a Tana man killed a woman with whom he cohabited here, and pleaded in justification that he was bound to kill her because she had admitted a man who belonged to a class (Mota Veve) forbidden to her by their own laws. Had she admitted any number of men who belonged to the lawful class, he said he could have made no objection. This apparent polyandry, therefore, is simply communism with an exceptional scarcity of women.—L. F.]

4. Relation of the Sexes.

Boys, as soon as they grow out of childhood, are sent to sleep in the GAMAL, or public club-house. It was considered to be the duty of parents to look after both boys and girls, and to correct them. Girls never went about alone, and it was no uncommon thing for them to remain chaste until marriage. Adultery was punished as the injured husband chose. He might shoot the man or beat his wife. It is remarkable that sexual intercourse between members of the same veve was thought disgraceful. If such a thing were known, the people of the "other side of the house" would damage the gardens and kill the pigs of those to whom the offenders were "sogoi." No resistance or retaliation would be made.

[The Mota Gamal—the Fijian Mbure; and the custom is the same in both places.

The abhorrence of intercourse between males and females of the same veve is common to all the numerous tribes who are divided into exogamous intermarrying classes like those of Mota. The offence is looked upon as incest, because all the members of a class in the same generation are theoretically brothers and sisters. They are still so designated by many tribes. The "other veve" has the right of revenge for a breach of this rule, because its marital rights have been invaded. The woman was one of its wives. The wasting of the property belonging to the offender's sogoi is in strict accordance with the rule among savages almost everywhere. With them responsibility is not personal but corporate.—L. F.]

5. Intercourse between Relatives by Marriage.

A man will not name his wife's father, but will sit and talk with him. He will not take anything from over his head or step across his legs.

A man will not come near his wife's mother, nor mention her name. They avoid one another, but will talk at a distance. If they meet, the one to whom it is more convenient gets out of the way. At Vanua Lava a man would not follow his mother-in-law along the beach until her footsteps were washed out by the tide, and *vice versâ*.

A man will not name his wife's brother, nor reach above his head for anything, nor step across his legs, but he does

not avoid him, excepting in that he will not sleep with him.

A man will not name his son's wife, but does not avoid her. Parents whose children have intermarried will not name one another, but do not avoid.

The objection to using the person's name extends to every part of his name. Thus Leveveg, having a son-in-law called Matevagqoe, could not use the word for pig, which is qoe. Hardly any one will mention his own name.

This avoiding and not naming relatives by marriage is reciprocal, and is ascribed to a feeling of shyness and respect, "an inward trembling."

[These customs are of world-wide prevalence. *Mutatis mutandis*, they may be said to be general throughout the South Sea Islands and Australia, as well as among many American, Asiatic, and African tribes.

In Fiji brother and sister are strictly tabooed. They will not even speak to one another. Mr. Codrington informs me that this is the rule at Lepers' Island also, though not at Mota.

Sir John Lubbock attributes these customs to the former prevalence of marriage by capture; but the facts will not fit in with this theory.—L. F.]

6. Adoption.

There is no notion of a milk tie. An infant is often adopted, either from pity or relationship, on the death of its mother. When adopted in infancy, the child is carefully kept in ignorance of its adoption, and becomes in all respects one of the family, whether it be of the adopted mother's veve or not. If the adopted child becomes aware of his real parentage, he will very likely go away; and such a discovery causes great unhappiness. If the child be adopted at an age such as enables him to understand the transaction, he lives as one of the family, but does not break his natural ties, or lose his own inheritance, nor does he necessarily succeed to his adoptive father's. The closeness of the relation in such cases depends upon affection and circumstances.

[It is manifest that the Mota custom does not amount to full adoption. This, however, is found in other South Sea Island groups. I do not think it is a purely Fijian custom, though it seems to prevail among some of the tribes who have been intimately connected with the Tongans, and may have learned it from them. A man will adopt the child of his deceased brother. The Rev. F. Langham, chairman of the Wesleyan Mission in Fiji, informed me of a case in which a man deliberately proposed to his wife that she should strangle her own child in order to suckle that of his deceased brother, whose wife also had died. This, however, is quite distinct from adoption proper, which brings into the household a member of another household. In the case in point the child was of its paternal uncle's own Vuvŝle (household), and, according to the Fijian system of relationship, the paternal uncle was its father equally with its own father.—L. F.]

7. Couvade.

When a child is born, neither father nor mother eat things, such as fish or meat, which might make the infant ill. The father does not go into sacred (rongo) places which the child could not visit without risk. After the birth of the first child the father does no heavy work for a month, lest the child should be injured. Before the birth of a child the father and mother eat as they please; but before the birth of her first child a woman must not eat fish caught by hook, net, or trap.

[A similar custom is observed in Fiji. Walter Carew, Esq., Commissioner for Tholo (Navitilevu Hill country), was good enough to send me the following note upon it:—"I have frequently observed that fathers abstained from certain articles of food from fear of affecting the child, born or unborn; and I have often joked the people about it. Once I persuaded a man to break the *tabu* and eat some fowl. Unfortunately the child died some time afterwards, and the father more than half believed me to have been the cause of its death."—L. F.]

8. Killing the Aged and the Sick.

If people, from old age or sickness, were lingering in misery, it was usual to bury them alive. Sometimes this was done because the relatives were tired of the trouble of waiting on the sick. Sometimes it was done at their own request, to put them out of their misery. Ten years ago a man at Mota buried his brother, who was in extreme weakness from influenza, but he heaped the earth loosely over his head, and went from time to time to ask him if he were yet alive.

[This custom was universal in Fiji. The aged and the sick were strangled or buried alive when they became too great a burden upon their kinsfolk. Frequently this euthanasia was a matter of common consent between the parties concerned. Aged parents would walk to the grave dug for them by their sons, or offer their necks to the strangling cord, with even less reluctance or emotion on either side than is manifested by a pauper family in England when its old folks are removed to the "Union." In fact, the grave was to the Fijian what the workhouse is to the poorest class at home, and thither he sent the unproductive members of his family as a matter of course. Tribes who make very curious artificial caves for their dead would place the sick man in the vault thus made, and lower food down the shaft of the grave as long as he had strength enough to reach and use it. When the food remained untouched the grave was filled in.—L. F.]

9. Infanticide.

Infanticide of born or unborn children was common, either from fear that the husband should think the child was before its time, or to spite the husband in revenge for something, or

from a desire to appear young, or to save trouble. Male children were killed rather than female, because of the family passing by the female side.

[The fact noted by Mr. Codrington that "male children were killed rather than female," together with the reason for it, is of great importance. Mr. M'Lennan's theory of exogamy is that it is "connected with the practice in early times of female infanticide, which, rendering women scarce, led at once to polyandry within the tribe, and to the capturing of women from without." (*Primitive Marriage*, p. 138). The Mota practice tells against this theory as far as it goes, and it goes a long way. For in "early times" descent was, as it is now at Mota, through females. That is to say, this line of descent can be shown to be earlier than the agnatic On many other grounds I believe Mr. M'Lennan's theory to be utterly untenable.

Infanticide was, and still is, very common in Fiji. There are several words for killing an unborn child. An old chief once defended, in my hearing, the practice of killing new-born children on the ground that "their souls had not yet come to them."—L. F.]

10. Ghosts.

It is most desirable to distinguish between ghosts, and spirits which are not the spirits of dead men. The Mota people use different words for them, and never think of them as the same. A ghost, in vulgar English, is a dead man—"tamate." A spirit, an incorporeal personal being, is a "vui." Neither the English "ghost" nor the Latin "spirit" makes this distinction, but to keep it we may use "ghost" for the dead man's ghost (tamate), and "spirit" for the being that never was incorporate.

A ghost, then (tamate), is the soul or "atai" of a man which has left the body. It does not go far at first, and may possibly be recalled. Hence the people shout the name of the person who is dying, or just dead, in hope that the atai may hear and come back. It is even supposed that an atai may be caught and put back. Not long ago a man heard a rustling just as a neighbour had expired, and believed he had caught the atai in his hand. He took it to the corpse and opened his hand over the dead man's mouth, but the expected revival did not take place. On the fifth day after death they shout and blow conchs to scare the tamate away, the dead body, which also is called "tamate," having been buried on the day of death or the day after.

The ghosts of the dead are believed to congregate in a common receptacle called Panoi, which has several entrances to it on the various islands. Whether they remain there for ever or perish after a while is a matter of doubt. There are houses at Panoi, and trees with red leaves, but all is unsubstantial. The ghosts live together as on earth, but they live

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A TAMATE (GHOST, OR DEAD MAN) OF THE SEA.

Facsimile of the Original Drawing by a native of Mota, Banks Islands.

an empty, aimless life. They neither work nor fight. Panoi is a dismal region—a worse, and not a better, earth, and is dreaded accordingly. The ghosts are separated according to the death they died, those who have been shot being together; those, also, who die of the same disease, and so forth. The condition of the ghosts in Panoi is not supposed to be affected by good or evil conduct during life; but some believe that the conditions of rich and poor, great and insignificant, are reversed. The ghosts eat excrement, particularly those who were rich in this world. In one particular only was there a notion of a future reward for goodness. Young men who had kept themselves chaste were supposed to live under somewhat less dismal circumstances, and to come out and dance on moonlight nights. Stupid, harmless persons, also, were thought to be better off than the rest.

After the ghost reaches Panoi, it is weak for a time, and cannot move about. The ghosts were supposed to leave Panoi by night and range about their island. They are greatly dreaded in the dark. Phosphorescent fungi are supposed to be their eyes. They are heard shouting and blowing whistles made of landcrabs' claws on moonlight nights at the "sura," the entrance to Panoi on the mountain at Mota. Some of them frequent the sea, and do mischief there, as their fellows do on shore. They are supposed to be malevolent towards the living. The accompanying sketch, which was made by a native, represents one of the sea-frequenting ghosts—in the language of books, "spirits of the sea." To represent them as belonging to the sea, or because the natives suppose they have suffered a sea change, they are drawn as much like fishes as may be. These, and the land-haunting ghosts, appear in travellers' and anthropologists' writings as spirits of the sea, the woods, the rivers, &c.; but the natives call them all "tamate," which is simply "dead men." So, also, what have been called "the spirits of the sea and air" at Anaiteum reveal the truth through the native word for them—*natmas*—which is neither more nor less than the Mota *tamate.*

There used to be in San Cristoval a canoe-house—temple, according to travellers—which was full of drawings. Now it is a ruin, and there is no hope of the natives doing anything like it again. It had a series of pictures all along the wall-plates and lower purlines, representing native life as naturally as the drawings in an Egyptian tomb—*e.g.*, feasts,

from the first climbing for the cocoanuts through all the processes of cooking; fights, fishing, accidents at sea—everything almost. Among them was a canoe attacked, as I supposed when I first saw it, by demons. It was not till long afterwards that I found out my supposed demons were only ghosts.

It is by ghosts (tamate), not by other spirits, that evils are inflicted on mankind. Some are vaguely dreaded, as that ghosts should eat men. The "ghosts of the sea" use flying fishes and others as spears or arrows. If one of these fishes strike a man he is supposed to have been shot by a tamate. Men and children were sometimes possessed by ghosts. When a man was possessed by a "wandering ghost," as the natives say, he was supernaturally strong and agile. He rushed from place to place, shouting and making peculiar noises. Such a man was seized by the neighbours and held in the fumes of strong-smelling herbs while they called the names of the dead men whose ghosts might be supposed to have possessed him. When the right name was called the patient cried out that "It was he," and forthwith recovered. A child was sometimes supposed to be possessed when it was lingering in wasting sickness. It had strayed, perhaps, on a grave, or some haunted place; and a tamate had entered it, and was drawing out its soul. Certain women knew how to cure the child by muttered charms, blowing on the eyes, and calling the name of the man whose ghost was supposed to be killing the child. When the right name was called the patient revived.

[I have observed among many tribes in Fiji, and in Australia also, what seems to be a notion that the ghost does not get free from the body until the fourth day after death. Hence, perhaps, the blowing of conchs at Mota on the fifth day to scare the "tamate" away. The *atai* has become a *tamate*, and is now to be dreaded. Among the lower savages I think the dead are always supposed to be malevolent towards the living; and even with those of higher culture the old dread lingers long. The Fijian, for instance, deifies his ancestors, honours them, and worships them; and yet he is terribly afraid of the lately dead, and adopts all manner of queer precautions against them. Propitiation suggested by fear lies, I believe, at the root of ancestral worship.

The very objectionable diet of the Mota ghosts seems to be the result of a fair process of reasoning. Ghosts are dead men, and such matters may not unnaturally be looked upon as "dead food." See Taylor's *Te Ika, a Maui*, for an account of a like belief among the Maories. It is not, as far as I know, a Fijian belief.

The chaste young ghost of Mota would fare badly if he were to betake himself to the Fijian Hades, for there is a terrible god with a terrible name in the path, who is utterly implacable towards bachelors.

I have seen somewhere a long list of demons who are to be called by name in cases of possession at the present day among Roman Catholics. This method of exorcism was used, I believe, as late as 1861, during the prevalence of the strange phenomena which appeared at Morzine.* This is a very curious instance of the survival of a savage custom in civilisation.

* See "The Devils of Morzine," *Cornhill Magazine*, Vol. XI., p. 468.

11. Spirits.

(*a.*) Spirits who correspond rather to deified ancestors, since they were born, married, had children, and yet were *vuis*. The chief of these was Qat, who was born in Vanua Lava, and had several brothers, whose names are Tangaro. Qat is said to have made men, and with his brothers was invoked in danger, yet can hardly be said to have been considered a god. They were all, nevertheless, vuis, not men—something more than men.

(*b.*) Beings like fairies, called Nopitu-vuis, yet occasionally visible in human form, and becoming invisible at will. They gave money and food to those whom they visited; came invisibly, and sang most sweetly in a child's voice; entered into people, who performed strange feats by their power; had children by women; and also, as females, lived with men.

(*c.*) Beings altogether incorporeal, and having certain powers in nature. Certain places were sacred (rongo), because of connection with a vui. So, also, are certain stones, which are said to be vuis in the shape of a stone, and are of good or evil repute, according to the origin of the connection between the vui and the stone. Stones which are of an unhappy character are avoided; those of happy associations are used as media for obtaining advantages. These had what may be called their priests—certain persons who knew the stone, and called its vui theirs; not as having power over the vui, but as being "near" it, having a connection with it. Such a man received money from any one who desired riches, a good harvest, or other kind of success, and offered some of it on the stone, making sacrifice (oloolo) with a prayer to the vui.

There does not seem to be any notion of a vui doing harm to men. They were certainly not propitiated as malignant powers. Diseases were not supposed to be caused by them directly; but perhaps a man might use the power he had acquired from a vui to bring disease upon his enemy.

[I am at present inclined to think that all the spiritual beings of Fiji, including the gods, are simply the Mota tamate. Williams, however, tells us that he met with a tradition of fairies at Vanua Levu, an island which must be distinguished from Mr. Codrington's Vanua Lava. His informant declared that he had seen them. "They were all little, like your sons," he said, and his eyes glistened as he told the tale. I have had no opportunity of investigating the customs of that island, save during two hurried visits of short duration. Its customs seem to be peculiar in several important respects, and it is there that

uterine succession is found. As to the little fairies, however, it should be noted that certain burial customs show that ghosts are thought to be of very short stature—at any rate when they first leave the body. And this is a reasonable belief, for they are supposed to have been contained within the body. The Fijian language has not words corresponding to the Mota atai and tamate. Yalo has to do duty for both, yalo ni mate (soul of the dead) being used when it is desirable to specify definitely a ghost.

In Williams's *Fiji and Fijians* an account of sacred stones, with illustrations, will be found. The Rev. F. Langham, before mentioned, has in his possession a stone which is evidently phallic.—L.F.]

12. Sacred Objects.

Men can *tapu* things for particular purposes, but that does not make the thing sacred (rongo). An inherent natural quality of awfulness, in greater or less degree, belongs to that which is rongo. Certain places are thus rongo, and no one will visit them, excepting those who are in some way "connected with" the places, and have a kind of right to go there. Stones in such places are sacred; so are banyans and serpents. Serpents that haunt a house are sacred, but no observance is paid to them. This applies to other islands, for there are no land snakes at Mota. Certain streams, or parts of a stream, are sacred—connected with a vui—places of sacrifice. The cycas (mele) is always sacred; and yet it is cut down without scruple if it be in the way. Some individuals have a superstitious feeling about sharks, owls, eels, lizards, and water snakes.

Small round stones, or stones of some shape that took the fancy, were assumed by men as a kind of fetish. They imagined that some vui was connected with them, and that they had an influence favourable to them. These stones were buried in the garden to bring a good crop, or hung up in the house in a bag. If a stranger came into a house in which such a stone was hanging, and meddled with things in an improper way, and afterwards met with an accident, the man of the house would give the credit of it to the stone —"My tangaroa did it." A man would take a fancy to a stone, and hang it round his neck, and think it brought him luck, made him shoot true, and caused his enemies to miss him. Tangaroa is a common name for some kind of deity in the Pacific. Tagar, or togaro, is the chief spirit in Aurora and Lepers' Island.

[Tangaloa in Tonga and Samoa; tangaroa, ta 'aroa, kanaroa in other groups.—L. F.]

13. Prayers.

In danger, as at sea, vuis were invoked, as well as ancestors, and relatives lately dead. The vuis also, as already stated, were prayed to at the sacred stones. These were prayers (tataro). Besides these, incantations were called prayers, which formerly were customary—*e.g.*, on pouring water into the native oven a prayer was muttered that enemies might be scalded. So also in the cure of diseases, in making rain, sunshine, or crops of yams or bread-fruit, though these were done with songs rather than prayer.

[I believe—though I should hesitate to make a positive assertion—that the Fijian did not use incantations as distinguished from prayers. A prayer is a petition to a god or spirit; an incantation is some sort of formula by which the god may be coerced, compelled to do what his worshipper desires. Prayer in Fiji generally concluded with malignant requests as to the enemy—"Let us live, and let those who speak evil of us perish. Let the enemy be clubbed, swept away, utterly destroyed, piled in heaps. Let their teeth be broken. May they fall headlong into a pit. Let us live, and let our enemies perish." These, however, are not incantations proper. They are direct petitions.—L. F.]

14. Magic Charms.

These, as distinct from incantations and fetishes, were of three principal kinds.

(*a.*) *Talamatai*—a bit of a dead man's bone wrapped in certain leaves while a song was chanted. This being placed in the path, the first who stepped over it was supposed to be afflicted with an ulcer.

(*b.*) *Garata*—a fragment of a man's food, hair, or finger nail, worked up with incantations to bring disease upon him.

(*c.*) *Tamatetiqa*—ghost-shot, bones and leaves enclosed in a small bamboo with charms. The man who wished to hurt another fasted to give his charm power; and then holding the bamboo in his hand with his thumb over the open end, he watched for his enemy, pointed the bamboo at him, and, lifting his thumb, shot him with the magic influence. Tamatetiqa is the word now used for a gun.

[Similar charms were commonly used in Fiji, and, indeed, by savages everywhere. In Fiji, however, I think the charm is supposed to have a certain inherent baneful influence of its own—for instance, the method of charging with dropsy, leprosy, &c. The sausau, or disease-bearing reed, does not seem to me to amount to an incantation proper. The Maori spells, on the other hand, are true incantations. They are real "words of power," and compel the spirits. (See a weird account of Maori enchantments in Sir George Grey's *Polynesian Mythology*, p. 168.)

The Fijians are terribly afraid of the garata. Some of our mission-agents, who faced boldly enough spears and clubs in the hands of angry men, quailed before it. I am convinced that natives frequently die of fear when they think themselves thus bewitched.—L. F.]

15. Doctors.

All serious diseases are ascribed either to charms such as are above described or to the direct malignant action of tamate. The gismana, or doctors, treated them with counter charms and incantations.

The gismana were not those who made charms to cause disease. They sincerely believed in their power, though they practised deceit. They sucked the part of the body where the pain lay, and then spat out something which was supposed to have been causing the pain. For a toothache they would apply a small roll of leaves with a grub concealed in it, which, when the toothache passed away, was shown as having been drawn out of the tooth. They would stroke the afflicted part, singing songs the while, or blow upon it after chewing certain leaves. Some things, also, they did with the notion of healing qualities in the leaves or poultices applied.

[Sir John Lubbock, after giving an account of endless charms against sickness in his *Origin of Civilisation*, makes the extraordinary assertion that "savages are rarely ill" (p. 45). This is one among very many ill-considered statements in which that work abounds. Savages are very frequently ill, and their languages are full of words for all manner of diseases, for charms to cause them, and for counter-charms against them.

The methods of the Mota gismana are repeated by the medicine men among savages everywhere. That they really believe in their power over sickness, as Mr. Codrington says, I am fully convinced. One of our native mission-agents in Fiji assured me very earnestly that he had the power of expelling disease-causing spirits, and he gave me a minute description of his treatment. He passed his hands over the patient's body until he detected the spirit by a peculiar fluttering sensation in his finger ends. He then endeavoured to draw it down to one of the extremities—a foot or a hand. Much patience and care were required, because these spirits are very cunning and will double back, and hide themselves in the trunk of the body if you give them a chance. "And even," he said, "when you get the demon into a leg or an arm which you can grasp with your fingers, you must take care, or he will escape you. He will lodge in the joints, and hide himself among the bones. Hard, indeed, is it to get him out of a joint! But when you have drawn him down into a finger, or a toe, you must pull him out with a sudden jerk, and throw him far away, and blow after him lest he should return."—L. F.]

16. Shadows.

The word niniai in Mota corresponds exactly to the English "shadow," as used by those who have not taken up the Latin word "reflection" for the image given by rays of light. It means a definite form, but unsubstantial, having no independent existence. It is not *shade* as in a wood or a house; and it is rightly applied to an image given by interception of rays of light, or by reflection. To

use the word to describe the individual unsubstantial being connected with the substantial body, but distinct from it, is very natural, and does not imply the belief that shadow and soul are the same thing.

17. Exit of Soul in Dreams, &c.

It is thought that the "atai" goes out of the body in some dreams, but not in all, and sometimes in sleep which has no dream. Persons are believed, and believe themselves, to have their atai go out of them in sleep to eat the newly dead, not the flesh of the corpse, but the lingering life. They are called talamaur. One such was watched for not long ago, and heard to approach a corpse. One of the watchers aimed at him with a stone, and in the morning the talamaur was found with a fresh bruise on his arm, which he said he had received as he went to the corpse.

18. Souls of Beasts or Inanimate Objects.

The Mota people had a notion that the pigs killed for a funeral feast, the food laid on the grave, and the ornaments with which the corpse was dressed, had their "atai" to accompany his; but they deny that under other circumstances pigs, or birds, or inanimate objects have "atai."

19. Dances.

Dances in Mota are absolutely devoid of religious or superstitious meaning. The men and women dance separately, and the dances are quite innocent. In *Bishop Patteson's Life* a letter of his is given describing a feast and common dancing to the drum as a religious ceremony. But he discovered next year that he had been completely mistaken. He had a Loyalty Island Christian with him, who interpreted every native custom at Mota in the worst sense, as is too often the way of converts. Sir John Lubbock's statement that "Dancing among savages is no mere amusement" is wrong for Melanesians.

[I have not been able to discover the slightest approach to religious sentiment in the Fiji dances. Some of them are very fine—real dramatic representations with dialogue and appropriate action; others are rhythmic movements to a chanted accompaniment, whose words are often very filthy. In some of the dances both words and gestures are grossly indecent.—L. F.]

20. Rattles.

The rattle is a common child's toy at Mota and elsewhere. The natives know nothing of it as "a sacred and mysterious instrument."

21. Cannibalism.

Cannibalism is altogether unknown in the Banks Islands, but is more or less practised nearly everywhere else in Melanesia.

22. Clothing.

Clothing was not used at all by males in the Banks Islands, excepting a very handsome dress worn in dancing only by certain grades of the Supwe *(see Supwe)*. The women wore a small double band, prettily made and ornamented. The art of making these dresses has almost died out by this time.

I think it clear that wearing any considerable amount of clothing is a mark of the Polynesian element, which shows itself in four particulars—cannibalism, clothes, chiefs, and *tapu*. When I say Polynesian, I mean the race which now occupies the islands to the east. The Tongans are those whom we know to have come in quite modern times to the Banks Islands; and by the language it seems clear that it is they who are represented by the Polynesian settlements at Mae and Fate. The Mae language is Tongan with very little change, and a Mae man understands the Fate.

But though in the Banks Islands the males wore absolutely no clothing, yet they had words for the thing; and, what is curious, these words are different in different islands. At Merlav (New Hebrides) they call it *gagao*, which is a Maori word; in most of the other islands they call it *malsam*, which is perhaps the Fijian *malo;* but in Mota they call it *siopa*. It is odd that, not having the thing, they should have a word for it peculiar to themselves.

[In Samoa and Tonga the native cloth made from the paper mulberry is called *hiapo* or *siapo*. This doubtless is the Mota *siopa*. Probably the Fijian *seavu* is the same word.

With reference to cannibalism as a "Polynesian" characteristic, it is to be noted that the Tongans were not cannibals. The contrary has been asserted, but without sufficient evidence. Some of the Tongan warriors, who visited Fiji and fought in the wars there, became man-eaters, but they were looked upon with horror by their countrymen. The question is settled by the fact that there are no cannibal words in the Tongan language. The Fijian, on the contrary, is full of them.—L. F.]

23. Sneezing.

It is thought that when a man sneezes somebody is talking about him.

[In Fiji a salutation is shouted to the sneezer by the bystanders—"May you live." It is proper to utter a good wish in return—"Thanks! May you kill," *i.e.*—kill an enemy.—L. F.]

24. Stone Clubs.

Mr. Stevens says, in his book called *Flint Chips*, that "Mr. Robert Day, of Cork, possesses a stone club from San Cristoval." I question whether the club was procured at that island. I have only seen one, and that was obtained in the Solomon Group. It is headed with a stone, which is woven over with cane, so that one cannot see whether it be drilled or not. It is an upright oval as fastened to its handle.

[I have in my possession three clubs, weighted with drilled stones, from New Britain. The handle of one of them, from which I detached the stone, is four feet two inches long, and is sharpened to a point at the lower end. The stone weighs nine ounces, seemingly a light weight for the purpose. But it needs only to take the club in one's hand in order to perceive that it is a thoroughly effective weapon. The poise is exact.—L. F.]

25. Wild Men.

Throughout the field covered by our mission there is everywhere a story, but with all sorts of modifications, that inland on the mountain or mountains there is, or used to be, a race of wild men, to whom different names are given in the different places. The stories might be those one reads from the great islands and peninsulas of Asia. These creatures live in trees and eat fruit. They are never seen more than two together, and single young ones are seen with the mother. They wear no clothes, but carry a bag, which seems odd. They cannot speak. They are seen high up on the great volcano at Ambrym sunning and scratching themselves. If they catch a man they tear him with their long nails, and some say that they will devour him. I have not heard of any that have tails, but I am settled in the belief that they are identical with the tailed men represented in the myths of New Guinea and New Britain. Does this widespread belief originate in the memory of apes in the ancient home of these people, or in that of men in a lower state

than themselves? Or is it a flight of the same fancy which has devised all sorts of fairies? In New Zealand there turns up from time to time the report that a wild tribe has been found inland, founded on a similar notion among the Maories. I remember twice to have heard of the discovery.

[I never heard of any such tradition in Fiji. The islands are too small for such a growth. But it is remarkable that, though the monkey is not a native of Fiji, the language has a word for "monkey," which does not seem to have been introduced from without. It is said that when Fijians still living first saw a monkey, they exclaimed, "A ngele! a ngele!" recognising the animal from the tradition of the ngele which was current among them. Mr. Codrington, to whom I mentioned the circumstance, suggests that the ngele may have been the opossum. There is an opossum in the Solomon Islands. —L. F.]

26. Totems.

There is something resembling a totem, though not a totem. Some people connect themselves with an object, generally an animal, as a lizard or a snake, or with a stone, which they imagine to have a certain very close natural relation to themselves. This, at Mota, is called tamaniu—likeness. This word at Aurora is used for the "atai" of Mota. Some fancy dictates the choice of a tamaniu; or it may be found by drinking the infusion of certain herbs, and heaping together the dregs. Whatever living thing is first seen in or upon the heap is the tamaniu. It is watched, but not fed or worshipped. The natives believe that it comes at call. The life of the man is bound up with the life of his tamaniu. If it dies, gets broken or lost, the man will die. In sickness they send to see how the tamaniu is, and judge the issue accordingly. This is only the fancy of some.

[Though this is not a veritable totem, I am inclined to think that it is connected with the totem. Too many words, however, would be required for the discussion of the subject here.—L. F.]

27. Counting.

Mota people count up to 1000 readily and accurately. I was once told at a feast the number of bananas—nearly 3000. On being recounted they amounted to the exact number specified. At another time I wished to buy 200 dried bread-fruit; 164 had been brought and counted, and a bystander immediately gave the number deficient. At the same time our scholars are very slow at arithmetic in our

fashion. Their mental view is different from ours, and is not readily caught by us.

Their system is natural and clear. Up to 5 their numerals are the common ones of the Pacific. On the second hand they are the same with a prefix up to 10, which is "sangavul." The unit above 10 is called the numei. Tens above 100 are called the avaviu.

Example.—127 is thus expressed:—

Melnol vatuwale, 0 avaviu sangavul rua, 0 numei laveârua.

"Hundred once, the avariu is tens two, the numei is the other two"—*i.e.*, 5 + 2, or seven.

Of course they use "ten hundred" and "a thousand" loosely also. A traveller knowing nothing of the language, and having to deal with a stupid person through an interpreter, would very likely report that the people could not count, and all the anthropologists would repeat the statement.

[Distinguishing between counting and calculation by using the former word for the mechanical process of counting visible objects—one, two, three, and so on—and the latter for the mental operation necessary in the case of Mr. Codrington's dried bread-fruit, I think we may say that the Fijians are good counters and bad calculators. They will count up to many thousands, but few of them would have been able to subtract mentally the 164 bread-fruit from the whole number required. The possession of words for high numbers has been taken as a mark of superior intelligence, but I think it is not necessarily so. There are tribes who count to high numbers simply because they have things to count, and they are in the habit of counting them. Thus root-growers like the Fijian often have enormous quantities of yams to count, and they count them correctly; but they cannot be called good arithmeticians, even in the smallest way, nor do our mission-students show much capacity for mental calculation. They soon learn to manipulate figures with slate and pencil, but they look upon them simply as things with which certain operations are to be performed; and it is extremely difficult to get into their minds the fact that figures are only symbols of real things, and to make them think out the simplest arithmetical process.

I have not read of any pastoral tribe who are good counters. The savage does not readily count moving objects. He must lay his hand upon the things he counts, and reckon them one by one.

There are certain numbers which are landmarks, so to speak, from which the counter "takes a fresh departure." Thus in Fijian, lima, hand, is 5; tini, finished (*i.e.*, both hands done with), is 10; ndrau, leaf, is 100; undolu is 1000, omba is 10,000; and vatuloa, blackstone, is 100,000. The etymology of undolu and omba is not apparent, though the former means "a company"—a *many*, as we still say in the provinces—in the language of Florida, one of the Solomon Islands, which is closely allied with the Fijian. All these words are evidently "tallies." There is no doubt that they are real numerals, and that the highest of them has frequently been brought into service in yam-counting. Mr. Codrington informs me that the Mota word for 100 (melnol) is the leaf of the cycas. It will be observed that the Mota people use 5 as their first tally. The Fijian goes on to 10, and then starts afresh with 10 and 1, 10 and 2, and so on. Though his first 10 is called tini, or *finished*, all subsequent tens are sángavulu—the Mota sangavul, a word whose etymology it is desirable to ascertain. It is common to many of the Pacific languages.

The word for "hand" in most parts of Fiji is *linga*, but *lima* is found in some of the Fijian dialects. This is simply one of those interchanges of consonants which are so frequent in these languages. I take this opportunity of

noting the fact that these interchanges are precisely those which children make before they learn to speak with full articulation.

As the ability to count up to high numbers is not necessarily a mark of superior intelligence, unless it be taken for granted that root-growers must be more intelligent than hunters or pastoral tribes, so also, as it seems to me, the inability to count beyond very low numbers does not necessarily prove a lack of intelligence. Sir John Lubbock tells us that there is no "more striking proof of the low mental condition of many savage races than the undoubted fact that they are unable to count their own fingers even of one hand." But why *should* they count their fingers, unless they have something to count on them? Savages are practical people, and it never occurs to them to sit down and count their fingers for mere amusement, or even as a curious study. The Australian has perhaps no articles of property more numerous than his spears, of which he usually carries two or three; and why, then, should he invent numerals beyond that limit? He soon learns to count when it becomes necessary for him to learn, and my friend, Mr. A. W. Howitt, F.G.S., informs me that the boys in one of the Victorian aboriginal schools gained the highest possible number of marks in the subjects (including arithmetic) in which they were examined by the Government inspector.—L. F.]

28. Money.

The common money of the Banks Islands is made of the tips of shells strung together. A finer kind is made for ornament. This money is money strictly. There are regular terms for borrowing, interest, and so on. The rate of interest is cent. per cent., without limitation of time; and there is a kind of forced loan, which the receiver is bound to take by a feeling of honour, but which he cannot make to the lender. Rich men thus keep others back by sending them an unasked-for loan, which they have to repay double.

[The Rev. George Brown, F.R.G.S., of the Wesleyan Mission to New Britain, states that shell-money, like that of Mota, is current there also. The tribes of New Britain seem to be born traders. Even husband and wife will not give one another so much as a morsel of food or a leaf of tobacco without money payment.—L. F.]

29. Supwe, or Suqe.

This most important institution is the chief bond of society in the Banks Islands, and extends certainly as far as the Three Hills in the New Hebrides, in substance the same.

The men who pass for chiefs are those who are highest in this society; and the names given by traders, naval officers, and others as the names of chiefs are often the words expressing the grade in the society to which they had attained. At Mota, and in the Banks Islands generally, the supwe practically includes every male, and every one's place and influence depend very much on his rank in it.

In every village is a long house, divided into compartments, each with its own oven, each compartment belonging to a certain rank. This house is the gamal, so called, with variations, in the New Hebrides also. Money has to be paid to all above in rank in order to rise to a higher degree, and in the higher ranks many pigs have to be given. In these ranks the members are few, and have great power, inasmuch as they have it in their hands to allow those below to rise, or to exclude them.

Formerly every male was obliged to eat in the gamal only, and if he ate in a private house he had to pay a fine. There is absolutely no superstitious character attaching to this institution, and it is no mystery. Women have something of the same sort among themselves, but no gamal. The Banks Islands people think the New Hebrides supwe very lax; but the New Hebrides great men in it seem to be greater men than any in Mota.

30. The Tamate.

This institution also has great influence, and spreads as far at least as Ambrym in the New Hebrides. It is a secret society, with many parallel secret societies, some trifling, some very select. No superstitious element can be discovered, though much mystery is cultivated. The name tamate—ghosts—and the pretence kept up was that it was an association with ghosts, and that the members, when they appeared, were ghosts. The meeting-places, kept strictly private, are close to every village. When the members are out gathering materials for their feasts, the uninitiated are warned out of the way by peculiar cries. When they emerge in public for dances or other shows they are disguised with masks and hats of extraordinary form.

Candidates for admission have to pay money to every member, and spend a certain number of days in the "salagoro," the private retreat of the society. To some of the societies admission costs a great deal of money. The men who belong to these, being the richest people, and, therefore high in the supwe also, have a great deal of power. For example, many years ago the man highest in rank in the supwe, and member of all the tamates in Mota and the nearer part of Vanua Lava—Mala by name—forbade all molestation of Bishop Patteson's party; and, in

course of time, he forbade the carrying or taking up of bows in Mota. Any one who took his bow had to pay a fine to the tamate. On one of my first days in Mota, in 1869, we heard all around one morning the peculiar cry of the tamates, and we were told that they were all astir because some one had taken his bow to shoot a man who had offended him. Later in the day we heard the man had given a pig as his fine, and all was quiet. One would have supposed from this that Mala was a powerful chief, but it was only his social power through the two clubs that showed itself.

[I delayed the compilation of this paper for several months in the hope of hearing from my friend, the Rev. George Brown, of New Britain, to whom I sent Mr. Codrington's account of the clubs; but I have been disappointed. I am persuaded that the tamate is the New Britain duk-duk. What I heard formerly of this institution from him coincides exactly as far as it goes with Mr. Codrington's description. I have in my possession a photograph taken by Mr. Brown of several persons in the duk-duk dresses and tall hats. The hats are 5 feet high, and the men who wear them look, when sitting down, like very small candle-ends under very large extinguishers. I have also a number of the masks; and most horrible things they are, being the front parts of skulls with artificial flesh and hair. One of the masks in the possession of the Rev. F. Langham is of quite another kind, and is really a most elaborate work of art.

These secret societies require a thorough investigation. They are widely prevalent, and they may tell us many things.—L. F.]

31. Laws.

There was and is no political constitution whatever in the Banks Islands; no chiefs, nor any men in authority excepting from their position in the societies. People were altogether equal, and the law was that of the man most ready with his bow, excepting in as much as customs, superstition, or social position acted as a restraint.

As there are no chiefs, nor government, nor tribes properly so called, revenge for injury and defence of rights are entirely private affairs. A bow and poisoned arrows were always at hand. Relatives of the injured person took revenge on any relatives of him who began the fray. Often villages became at enmity, village against village—as within a village a family connection against another family connection. Some one generally acted as a go-between, and the quarrel was settled by payment made. If the thing had gone on far, and many people or two groups of villages were concerned, the reconciliation was a ceremony with speeches.

32. Morality.

To judge of a people's notion of morality is very difficult without an intimate acquaintance with them; and this is one of the many matters on which writers with a theory to maintain can make customs and language mean almost what they please. As to life and property, no doubt murder and theft were not considered at Mota as they are in a civilised community; but a violent man and a quiet man, a thief and an honest man, were looked upon as very different characters; and there are no lack of words for various kinds of badness which convey disapprobation. So also words are in common use for a liberal, a compassionate, an industrious man, which certainly are used as terms of approbation. How far this use of words—this approbation or disapprobation—was moral, depends upon what people choose to call morality. Morality can be denied to any people if words may be treated as they are by Mariner.

[Sir John Lubbock accuses savages of being "almost entirely wanting in moral feeling;" but this accusation seems to me to be entirely unjust. The question here is not as to the comparative excellence of two moral codes, but as to whether savages have any moral code at all; and no one who knows anything about them will assert that they have none. Not only have they a well-defined code of their own, but they are far more strict in observing it than civilised men are in observing theirs. There is no such thing as a lawless class among savages; nor is there any such thing among them as a man's being held in honourable esteem though he deliberately and habitually offends against the code of morality by which he professes to be bound. That social hypocrisy is the exclusive property of civilised nations.

Mariner's treatment of words, referred to by Mr. Codrington, furnishes us with a good example of that liability to mistake which besets men who have only an imperfect acquaintance with a people whenever they begin to reason on what little they know. Mariner, or rather the savant who compiled the work which goes under Mariner's name, says of the Tongan language that "there are no words in it essentially expressive of some of the higher qualities of human merit—as virtue, justice, humanity; nor of the contrary, as vice, injustice, cruelty;" and this statement is gravely quoted by Sir John Lubbock in support of his assertion that "savages are almost entirely wanting in moral feeling." The fact of the case is that all those words are abstract nouns, and few such nouns are found in any language spoken by savage tribes. But I could quote plenty of adjectives from the Tongan language which express the quality of any particular action in terms of approbation or disapprobation, as the case may be—good or bad, just or unjust, cruel or merciful, and so forth. The moral code of the savage is indeed a low one as compared with that for the possession of which we have not ourselves to thank; but it is the best he knows, and he acts up to it.—L. F.]

CONCLUDING REMARKS.

[The ground covered by the Melanesian Mission—from the Three Hills, Anaiteum, to Ysabel, in the Solomon Group, together with other islands beyond their line, presents one of the most promising and least known fields of research to the anthropologist, especially with regard to the social constitution of the people. We find among them unmistakable traces, such as are found almost everywhere else, of an ancient commune, broken up by that

division of the community into exogamous intermarrying classes, which I am persuaded will sooner or later be recognised as the first step towards the formation of the gens. But the natives of whom Mr. Codrington tells us appear to have been "shunted off," as it were, to a line very different from that along which so many other tribes have advanced. I venture to hazard the conjecture—which, however, must be taken for no more than a conjecture—that the cause of this divergence may be looked for in the unexpected presence among them of what is undoubtedly a real currency. This seems to have created among them a sort of plutocracy, tempered by the ready use of the "bow and poisoned arrows," which may be looked upon as the protest of commune against aristocratic pretensions. But how did they come by their money, and their interest of cent. per cent., so upsetting to one's pre-conceived notions that usury, like the gallows, is a mark of civilisation? Their money differs, I believe, from that which is called "cowry money" elsewhere. (I send herewith a sample from New Britain, which is said to be identical with that current in the Banks Islands.)

There seems to be no distinction of birth whatever, and nothing like hereditary rank in the Melanesian Islands, excepting in the Polynesian colonies which are scattered here and there in those seas. Herein they differ widely from the Fijians and others, among whom there are serfs, commoners, and nobility of various grades up to the great chief, who is so high born as to be god born.

The Melanesian secret societies are especially interesting, and will richly repay investigation. At the risk of exciting a little harmless ridicule, I venture to express an opinion that we may yet find traces of Free Masonry among savage tribes. Victorians, at any rate, will remember how Stuart the explorer, in his diary, which was published in the Melbourne *Argus* (1862 or 1863), declared that a blackfellow in the far interior made him a Masonic sign, to which he responded with the happiest effect. Masons who read that account would see at once that there could be no possibility of mistake on Stuart's part—that either the signs were actually exchanged, or Stuart went out of his way to palm off a deliberate lie upon the public. I leave those who knew that gentleman well to decide as to which of the two alternatives is the more probable. There is, perhaps, no subject on which it is easier to raise a laugh of derision than this; but if we can find in savage and barbaric tribes the successive stages of progress which connect the old commune with the Roman gens and the Aryan household—and these we can most assuredly find—I see nothing to laugh at in the conjecture that we may discover among them some earlier form of an institution of such undoubted antiquity as Free Masonry.

I have not touched upon the subject of language in this paper. It is far too wide a subject to be dealt with here; and it is, moreover, outside the one special line of research which I have followed for many years amid surroundings and under auspices more than ordinarily favourable to its prosecution, and on which alone I may venture to speak with some little modest approach towards authority. Quite enough, however, has come under my notice to show that the Pacific Islands beyond Polynesia afford an especially valuable field to the philologist. Though there are great differences of language and custom, and even of physique, yet, as Mr. Codrington remarks, "the common substratum of race and language from Fiji to New Guinea is unmistakable, and it crops up in one word and another and in one custom and another continually."

This, however, does not indicate intercourse between the people of the various islands and groups of islands. In some cases the closest alliance of language is found in two islands far distant one from the other, while between them there are many others which at first sight appear to be hardly allied to them at all.* "Words," Mr. Codrington writes; "are very little guide in tracing connection by intercourse. The way they lurk beneath the surface, and show themselves here and there throughout Melanesia, and indeed from New Zealand to Madagascar, through all the islands, does not point to communication between the people, but to a common original element. Bishop Patteson used even to declare that Japanese is a Polynesian language."

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* This is the case also with the languages of some of the Australian tribes.

The most thorough knowledge of any one Pacific language and people does not qualify a man for this investigation. In fact, the man of one language is apt to be rather in the way, because in nine cases out of ten he is sure to consider it something very special, and to want to make it the rule for all the rest. Of the field occupied by the Church of England Mission, Mr. Codrington writes—"What is wanted, and very much wanted, for the understanding of an archipelago such as ours is a general acquaintance with all the dialects and customs." And this is only one portion of the vast area which has yet to be investigated. The wonderful knowledge of dialects possessed by Bishop Patteson died with him, for he had "next to nothing written down." His episcopal work in the young and growing mission kept him ever on the move; but, if his life had been spared, he would doubtless sooner or later have placed on record that extensive knowledge of the island languages which he seemed to acquire by a sort of intuition. Comparative philology owes a bitter grudge against the man-stealing wretches whose villanies were the cause of that lamentable murder.

Not the language only, but the customs also, of the islanders require investigation; and for this something far more trustworthy than travellers' observations is required. A thorough acquaintance with the people and their language is indispensable to secure anything like accuracy. The facts which travellers observe among savages are always valuable, but the inferences they draw from the facts are extremely untrustworthy, unless we can be sure that they have been able to get inside the native mind, and to look at the facts from its standpoint. Few observant men who have lived long among savages will disagree with Mr. Codrington when he remarks—"I have the most complete disbelief, as a prejudice, in any traveller's statement of what he does not see with his own eyes, and in his explanation of the meaning of what he sees. Many of our anthropologists' books are full of such statement; and the more I read of those books the more I am persuaded either that the Melanesians at all events are not savages, or that travellers' stories about savages are very untrustworthy. They put into the natives' minds and mouths either what they expect will be there, or what is in their own thoughts. Then, the natives take English words from the traders and others and use them, thinking it enlightened to speak like a white man; but they use them in their own sense, which is not always ours. Consequently, people who visit these islands nowadays are told that "plenty devil up there," the native informant meaning no more than that the place is tapu, or rongo (sacred); or they hear a common grave called a "devil stone," or one of the "*tamate*" masks, shaped like a man, spoken of as "all the same devil." And in the next edition of some anthropological work these sayings are made to prove something of which the natives had never the slightest notion.

Nor is a residence of a few years among these tribes of any great service towards securing accurate information. To judge from my own personal experience, when a European has been living two or three years among savages he is sure to be fully convinced that he knows all about them, and he is prepared to instruct the universe concerning them. When he has been ten years or so among them, if he be an observant man, he finds that he knows very little about them, and so begins to learn. When I speak of my own personal experience in this matter, I mean my experience, not of others, but of myself. This experience, however, has certainly not been contradicted by what I have observed in others, especially since the annexation of Fiji to the British Crown.

I have nothing farther to add, excepting that Mr. Codrington's reminder as to his observations on Mota customs—"Remember they are only notes"—should be borne in mind. Not, indeed, that there is anything as to either their matter or their manner of which he has any cause to be ashamed. Only the fact should be noted that they were written not for publication but in the way of ordinary correspondence. They are, however, none the less interesting or valuable on that account. Mr. Codrington's letters are always pleasant reading, and they are as instructive as they are pleasant.—LORIMER FISON.]

Art. VI.—*Some New Localities for Minerals in Victoria.*

By J. Cosmo Newbery.

[Read 11th July, 1879.]

A new locality of zeolites has been found by Mr. Norman Taylor at the corporation quarries, Merri Creek. Mr. Taylor found fine druses and crystals of phacolite and phillipsite, many of the crystals being larger than any previously discovered. Since then Mr. Rule has found very fine crystals of aragonite, perfect hexagonal prisms and pyramids. Mr. Taylor has given me the following note of the mode of occurrence:—"The basalt at the Merri Creek corporation quarries has been erupted in different flows. The surface is vesicular and partly decomposed, passing downwards through largely vesicular into dense rudely columnar basalt. The cavities in the vesicular parts are coated with carbonate of lime. Below this is a very vesicular decomposed basalt, the surface of an older flow. In some places it is changed into soapy clays. The cavities in many parts are coated with mammillated ferrocalcite, and a soft white hydrous dolomite of about the consistence of soft putty. It sometimes may be procured in masses several inches in diameter." Some of the lumps are covered by a thin crust of hydrous silica. The soft masses seem gradually to part with water, and become converted into a variety of dolomite. An analysis of a dried portion gave:—Carbonate of magnesia, 71·34; carbonate of lime, 25·80; carbonate of iron, 1·30; water, 1·10; total, 99·54. In some of the cavities this mineral is in the form of the so-called "rock milk," but that mentioned by Dana is carbonate of lime, not magnesia. The water, separated from the solid mineral, contains lime, magnesia, and silica in solution. The basalt becomes denser below this to the floor of the top quarry, which seems to be the top of a still lower flow; in this top quarry are found rarely the fine crystals of aragonite mentioned. The ordinary radiating masses of aragonite are common. The zeolitic minerals begin to occur at the floor of this quarry or ledge; as yet only phacolite and phillipsite have been identified. The basalt they occur in is dense, and contains cavities of all sizes, the bottoms of which are covered with a deposit of greenish, greasy clay, usually

covered with a thin, crystalline, transparent, zeolitic crust (undetermined), but not either of those already found. On this occur calc spar and dog-tooth spar in orange-brown crystals, and often on them again have been deposited the phacolite and phillipsite, which also line the upper portions of the cavities. Sometimes the zeolites occur perfectly crystallised on the ends of thin needles of calc spar, a fresh cavity looking as if the needles held glittering drops of dew in suspension. The zeolites often occur together in the same cavity, and seem to have been deposited simultaneously. Peculiar lumps, generally loaded with fine crystals, occur in many cavities. As these lumps are part of the basalt mass, they have probably been formed by pressure on the cavities during the cooling of the molten basalt." The zeolites appear to be more numerous where water has percolated through the basalt. The water contained in the cavities is highly charged with mineral matter. Only a small quantity has yet been obtained for examination. This gave a residue on evaporation equal to 1 per cent., consisting of chlorides of calcium, sodium, and aluminum, with silica and ammonia, and may be looked on as the mother liquor from the crystalisation of the zeolites. Another zeolite, stilbite, has recently been found, for the first time in Victoria, as a crystalline vein in the mesozoic sandstone near Ceres Bridge, Barrabool Hills. Bindhiemite—hydrous antimoniate of lead—is another mineral new to us; has been found with the steinmanite from the Murindal lead mines. Mr. Rule has reported the occurrence of both these minerals. Pyrolusite, new to Victoria, is found as the cementing medium of a brecciated quartz conglomerate in the ranges, some fifteen miles from Moe, Gippsland. The crystals are small, almost microscopic. Tungstite, also new, occurring with wolfram and scheelite, is reported by Mr. Rule from a reef in a hill near the cemetery, Maldon. Scorodite.—Some interesting occurrences of this arseniate of iron have been found at Bethanga and Dry Creek, Strathbogie Ranges. They are both auriferous. The Bethanga specimens are massive and earthy, and of concretionary formation. The Strathbogie scorodite is in thin veins in a large auriferous dyke, these veins being evidently the result of the decomposition of arsenical pyrites *in situ.*

Art. VII.—*The Tidal Datum of Hobson's Bay.*

By R. L. J. Ellery, F.R.S.

[Read 14th August, 1879.]

The chief object of these brief notes is to place on record in the transactions of our Society as succinct a history as I am able to gather of the tide or sea-level datum of Hobson's Bay. The history of measurements hitherto made is somewhat broken, and when, on several occasions, questions have arisen regarding high-water mark, mean tide level, &c., search had to be made in various directions, and the results obtained were found to be doubtful and discrepant. As it is of the highest importance in all matters concerning the conservation of our port, as well as in the disposal of littoral lands, that we should possess trustworthy and precise data, I propose, after sketching a brief history of the question, to furnish the height of various bench marks and points with reference to accurate measurements made a few years ago by Mr. A. C. Allan and myself, with the hope that the vagueness that has hitherto surrounded this question may be set at rest.

A self-registering tide-gauge was first erected in the waters of Port Phillip at Williamstown in 1858, by the Harbour Department, and placed in charge of the Observatory in June of that year. Soon after, however, it was transferred to the care of the Admiralty surveyors, and it was not until January, 1874, that it came again under the supervision of the Observatory. Since that time a careful and continuous record of the tides has been secured and tabulated every week. Prior to the erection of the gauge the tidal datum was obtained by regular eye observations of the surface of the water at the mouth of the river, and at one or two other places in Hobson's Bay. These observations, however, were taken principally for the purpose of indicating to the shipping the height of water in the river, and furnished no accurate data as to sea level.

In the earlier operations of the marine survey by Captain Ross, a datum was established by means of a graduated tide board, referred to the bench mark on the sill of the lighthouse, Gellibrand's Point, which was, and is, I believe, still

used as the datum of all our railway and other systems of levels. No very precise information as to the vertical distance between this bench mark and the tidal datum adopted in the earlier part of the survey of the bay can be found, but Captain Cox, in 1864, after discussion of two years' records of the self-registering tide-gauge, adopted the following:—Sill of lighthouse above high-water springs, 7·27; low-water do., 9·94; mean tide, 8·60. On a subsequent examination of these numbers it was found that a very obvious error had been made in referring the tide-gauge scales at the tide-gauge house to the lighthouse datum, and that they should have been as follows:—High-water springs, 5·95; low-water do., 7·62; mean tide, 6·78. This distance at low-water springs was subsequently adopted by succeeding Admiralty surveyors.

Nearly all the Admiralty surveyors, as well as others who occasionally made surveys in connection with the silting up of Hobson's Bay, affixed, for facility of reference, a graduated scale to the outside of the tide-gauge house, and dipping the water. These were fixed alongside of and sometimes over one another, and although several have got destroyed by boats, there are still five, differing more or less among themselves. No doubt this proceeding has been a fruitful source of errors, as well as of discrepancies, in compared results of surveys.

In 1871 a law case, involving the accurate definition of high-water mark on a part of the shores of Hobson's Bay, led to an investigation of the tide records and a revision of the various tide data. This was undertaken by Mr. A. C. Allan and myself, as already mentioned, and we made a very careful series of measurements of the vertical distance between the sea surface and the various *datums*. Thinking it would be convenient, and perhaps facilitate future references, if an imaginary datum below the lowest probable tides were adopted, we reduced all our measurements to a zero 10 ft. below the sill of the lighthouse, and the following will give various points referred to this zero:—

	Feet above datum.
Tide Zero	0·00
Sill of Lighthouse	10·00
N.E. corner Dock Basin	10·55
Low-water Springs	2·38
B.M. niche Prince's Bridge	17·69
Door-step of Observatory	93·31

One reason for adopting the new zero was that negative numbers and measurements in dealing with tide-gauge records, or soundings in surveys, would be thus avoided.

It is to be regretted that no precise references of mean tide level in the earlier days can be found. Where measurements do exist they are lacking in accurate information as to state of tides, and I can find nothing trustworthy upon which to base any statement as to change of sea-level since surveys have been made. I think it desirable that permanent bench marks on the natural beds or faces of rocks *in situ* should be established around our bay, carefully connected by accurate levelling with one another and with the tide-gauge, for it is very doubtful if bench marks on buildings can be assumed to afford a permanent datum.

Art. VIII.—*On the Method of Calculating the Increment in the Value of Land.*

By Alexander Sutherland, M.A.

[Read 14th August, 1879.]

It ought to be well enough known in these enlightened times that a sum of money invested for a long term of years at a fair rate of interest, without being disturbed, will be converted into a sum quite enormous compared with the original investment; and yet the public mind is from time to time disturbed by fallacies originating in a comparison of first sum and its result without allowing for the action of compound interest. A man, for instance, may have spent £100 in buying a piece of land fifty years ago; he may have done nothing with it, and yet the land may now be worth the handsome little fortune of £11,731. When people learn this fact they are surprised beyond measure, and imagine the case quite exceptional; they fancy the man has got an enormous profit, and some of his poorer neighbours look upon the process as almost dishonest; whereas, as a matter of fact, he has got only 10 per cent. per annum on his investment. The present form that this fallacy takes is the demand that Government should retain possession of the

land of the colony and let it on long leases. Whether it should do so or not is a political question that we have nothing to do with. There seem to me to be many reasons why it might do so with advantage; but in this note I only seek to call your attention to an obvious mathematical fact that is commonly ignored in a most unaccountable manner.

In reckoning the rate at which the value of land increases, we must always adopt the methods of compound interest. No one pretends that, if a piece of land during the present year increases in value, this increment is at the end of the year taken out of the land; the increased value of the land has to remain throughout the next year as the capital invested, and the rate must be calculated upon that. To calculate it every year upon the original price of the land would be absurd. And yet this is what has been done by a recent writer in the *Melbourne Review*, who seeks to prove that the value of the land in Melbourne has increased at the rate of 139 per cent. per annum. If this statement is put forward by a well-informed writer, we may guess what misconception prevails generally. If £100 had originally been spent in the purchase of land, and it had increased in this rate, the value in the second year would be £239, for none of the increased value has been taken out of it. Now, if it still increases at the rate of 139 per cent. per annum, this must be reckoned on the £239, and not on the original £100. To show how utterly astray the calculation is, I need only mention that at this rate, even assuming so short a period as twenty-one years, the present value of the land of Melbourne would be £24,190,000,000,000 instead of its real value, £8,286,000.

I have no doubt that to any one conversant with mathematics it will seem a very elementary proposition that the method of compound interest is the only one allowable in such a case, but I should like to have the matter discussed before our society, so that the true method to be adopted may be settled, and possibly our legislators prevented from rushing into hasty measures grounded on fallacious reasons.

The question of rents has come in as a disturbing element. Not only here, but in England and France, it has been tacitly assumed that, as a man gets from year to year, in the shape of rent, what is reckoned as a fair interest, the increment can then be calculated as at simple interest. But I need hardly point out to a mathematician how faulty such a process would be. The only correct method is to calculate

as compound interest the total increment, and then add in the yearly rate per cent. given by the rents. Thus £100 worth of land increasing at the rate of 10 per cent., and producing a rental of 5 per cent., will give these figures :—

First Year .....Value £100.....Rent £5
Second Year.....Value £110.....Rent £5 10s.
Third Year .....Value £121.....Rent £6 1s.

And so on. Now take the third year, when the value of the land is increasing by the sum of £12 2s., while for rent it produces £6 1s. The total yield of the land is £18 3s., and yet if this be calculated as interest on £121, which is the value of the land, and which the owner could have got for his land if he chose, it will give only 15 per cent., and this is the sum of 10 per cent. increment and 5 per cent. interest.

The calculation of the exact rate at which the value of the land in Victoria has increased would involve the solution of an equation of the forty-second degree, and the labour so involved would not be compensated by the degree of accuracy obtained.

The following equation will give the rate of increase in the value in Victoria—

$$330{,}629\ R^{40}+ \quad 77{,}213\ R^{35}+ \quad 116{,}935\ R^{30}+$$
$$1{,}453{,}383\ R^{25}+ \quad 2{,}144{,}999\ R^{20}+ \quad 2{,}054{,}839\ R^{15}+$$
$$1{,}689{,}181\ R^{10}+ \quad 2{,}610{,}085\ R^{5}=\mathrm{V}$$

where V is the value of all the land in the colony.

In this equation, in order to reduce the terms from forty in number down to eight, I have grouped the land sales together for periods of five years, and taken the middle of such periods as the average time of the sales.

A difficulty arises in determining V. The year-book of Mr. Hayter gives £65,000,000 as the total rateable property of the colony, but this includes all the buildings in cities, townships, or farms, together with all improvements on farm or pastoral lands, and to get the value of the land by itself seems impossible.

If the rate per cent. be taken as 5, then the above equation will give $R=1{\cdot}05$, and the value of V is £24,000,000, which is perhaps under the mark, but whenever the real value of V is attained some such equation as the above must be used in order to give tolerably accurate results.

About 6 per cent., I think, might be found to be the real value of the rate of increment. To this add the rate received from rents, and the total will be the interest obtained by the aggregate of landholders in Victoria.

More definite results can be obtained when we take more confined areas. The most startling results are generally adduced from land in Melbourne. The complete returns of land sales in Melbourne proper I have not been able to obtain, but the following results will give something like the correct rates. In the case of the sites in the very heart of the city, the calculation can best be effected by taking the average value of the land sold in 1837 and comparing that with the average value at present. The average price per acre paid in 1837 was £70, the average value at present is about £25,000 for the central portion. This seems an enormous rate of increase, but it is not so in reality.

$$70\,R^{42} = 25{,}000$$
$$\text{Log. } 70 + 42 \log. R = \log. 25{,}000$$
$$1{\cdot}8450980 + 42 \log. R = 4{\cdot}3979400$$
$$42 \log. R = 2{\cdot}5528420$$
$$\log. R = {\cdot}060782$$
$$R = 1{\cdot}152$$

Hence the rate per cent. is 15.

But those who bought land here in 1837 obtained it under exceptional circumstances. It was they themselves that gave the land any value whatever. Take the case of those who bought land in 1840. The average price was then £842 per acre. Its average price is now £25,000. Hence—

$$842\,R^{39} = 25{,}000$$
$$39 \log. R = \log. 25{,}000 - \log. 842$$
$$= 4{\cdot}3979400 - 2{\cdot}9253121$$
$$= 1{\cdot}4726279$$
$$\log. R = {\cdot}037751$$
$$R = 1{\cdot}0908$$
$$R - 1 = {\cdot}0908$$

Therefore the rate is 9 per cent. per annum. To this add the rate received for rents, and about 13 or 14 per cent. is the real rate received by the landholder.

The proposition I should like to bring forward for your consideration is this:—

If r^1 be the rate per cent. per annum yielded by the rent of a piece of land, and r be the rate per cent. per annum of the increment in its value—

If V^1 be the price originally paid for land, V_2 the value after n years, then the value of r is obtained from the equation—

$$\log. (1 + r) = \frac{\log. V_2 - \log. V_1}{n}$$

If R be value of r obtained from this equation, then $R + r$ is the annual rate per cent. received by the investor on his money.

Art. IX.—*Hughes' Induction Currents Balance and Sonometer.*

By Robert E. Joseph.

[Read 14th August, 1879.]

On the 15th of May last Professor Hughes read before the Royal Society, in London, a paper on "An Induction Currents Balance, and Experimental Researches made with it;" and the subject appeared to me to be of so much interest, and capable of being utilised to a very great extent in physical research, that I considered a few notes on the matter would prove acceptable to the members of our own Society.

Attempts have frequently been made to construct induction-balances for many years past; but they do not appear to have given satisfactory results. The introduction of the telephone, however, as an instrument that will detect currents of too feeble a nature to be detected by any other instrument, has caused what before was found to be a difficulty to now become quite easy, besides being simple and reliable.

The instruments I introduce to your notice this evening are the induction-balance, sonometer, clock-microphone, and telephone, which, with a battery and reversing key, will enable us to make any experiments we may require. Before, however, proceeding with these experiments, it will be as

well, I think, to describe the nature of the apparatus for the benefit of those who may not have read the paper I before referred to.

The induction-balance consists of two small wooden cups, having a couple of spools, on each of which is wound about 100 yards of 36 silk-covered wire; the lower bobbins are fixed, and form the primary circuit; the upper ones are adjustable, and form the secondary circuit.

If we now join the primary coils together, placing in their circuit a battery and microphone on which is placed a small clock, and join the secondary coils together with a telephone in its circuit, we shall, on listening, hear the clock ticking by the action of the current induced in the coils. If we now arrange the upper coils in such a way that they oppose each other, we can, by adjusting the distance between them, arrive at a zero-point at which we shall fail to hear the faintest sound of the microphone. In this state the balance is fit for use, for, if we introduce any metallic substance in either of the cups, we immediately disturb the balance and hear the clock ticking with an intensity of sound that depends not only on the nature of the substance introduced, but also by its weight or bulk.

Suppose we place a piece of silver in one cup, it will give out an intense sound; and we find that we must place in the other cup a piece of silver exactly alike, as regards size, weight, standard, &c., to balance the coils that are to produce the silence point again; and so sensitive is the instrument, that, with 24 Leclancher's cells, I have not yet succeeded in balancing exactly any two silver coins, although I used perfectly new ones for the experiment. Gold ones were much easier to balance, using the same battery; but the sound given out by a gold coin is not nearly so intense as that of silver, and I am inclined to think that it will be necessary to use a larger battery with different metals; because, it appears to me, that, in balancing any metals by sound, we of course depend upon the delicacy of our sense of hearing. When the balance arrives at nearly its zero-point we may not be able to distinguish any sound with, say, a battery of 20 cells; but by doubling the battery-power we increase the sound in the microphone, and thus render the instrument more sensitive. I should like to try the effect of a large battery, say, of 40 or 50 "Groves," on a balance, the primary coils of which were wound with coarse wire, as I imagine this would detect

even small differences in alloys which are not perceptible in using a weak battery-power.

For the purpose of making a perfect balance it is necessary that both coils should be exactly alike as regards size and length of wire; it also requires that the substance to be measured must be placed exactly in the centre between the coils. I find you can produce a difference in the intensity of the sound by varying the position of the substance, the loudest being, as I before stated, when the article is in between the centre of the coils.

The sonometer, which is used in conjunction with the balance, is similar in construction and action.

It consists of two primary coils, sliding between which is the secondary coil, the primary coils being wound so as to oppose each other. It follows that if both coils were the same as regards length and size of wire, the centre would be the zero or silence point; but in the one under your notice I have wound them of different lengths, so as to obtain a wider range of measuring.

By means of this instrument we can obtain the exact value of any person's hearing powers, which, as you will presently see, varies very considerably.

The use of this instrument alone appears to me to open up a very interesting subject of research. I am unaware of any other instrument that will enable us to ascertain and tabulate the strength of our hearing powers, from day to day, or to compare the sensitiveness of our sense of hearing. Suppose, now, we join the sonometer in circuit with the balance, placing in its circuit a reversing key, so arranged that we can switch-on either the balance or the sonometer. If we now place any substance in the balance we get a sound of a certain intensity; and by switching-in the sonometer, and adjusting its secondary coil, until we obtain a sound of similar intensity, we can read off the value of that substance; and so sensitive and accurate is its performance, that with a very little practice we are enabled to detect the nature of the metal, although we need not see it placed in the balance. Again, we may obtain the sound value of a coin; it will then be only necessary, supposing any one were to place an unknown number of coins in the balance, to obtain the sound value of the total number, and we can easily calculate the nature and number of coins placed in the balance. To ensure this expriment being satisfactory, it is necessary to adjust both coils at a much

further distance apart, so as to still bring the increased mass of metal in the centre of the coils.

I have been experimenting up to the present time with a view of being able to obtain visual instead of acoustic results, but so far without decided success; the extreme feebleness of the induced current as it approaches its zero-point fails to influence any form of galvanometer; and although the principle can be exhibited by a very sensitive form of galvanometer when a considerable disturbance of the balance takes place, the practical value of the balance is lost by its insensitiveness.

I think I have now explained sufficiently the construction of the apparatus; it is so easily made and used that it should find a place in all future physical researches, and thus by extending its use we may discover its exact value as a new instrument of measurement.

Art. X.—*Notes on the Geology of the West Tamar District, Tasmania.*

By Norman Taylor, of the late Geological Survey of Victoria.

[Read 9th October, 1879.]

The country which I examined in the month of January last contains an area of about forty square miles in the parish of Phillipsnorton, county of Devon, Tasmania. It is situated in the neighbourhood of the West and Middle arms of the River Tamar, a district which at one time gave promise of being a large iron-producing one, but which has, unfortunately, after several trials and much wasted capital, been temporarily abandoned, simply from the unforeseen occurrence in the iron ores of an *oxide of chromium,* the presence of which renders it impossible to turn out good marketable pig iron.

The roughly triangular area, whose base would join the heads of the West and Middle arms of the Tamar, consists at its northern apex of greenstone, rising at Ilfracombe village to a long ridge, capped with older pliocene tertiary

grits and cements. It also forms a range of hills on the north side of the West arm, called Stockyard Hills. This greenstone is followed to the west by rocks of carboniferous age, dipping north-easterly under it, and much obscured (except along the coast line, and at the heads of the arms) by both older and newer tertiary drifts. Further west again follow the silurian rocks, forming ranges of hills, with a general north-westerly trend, against the eastern flanks of which the carboniferous rocks lie unconformably. Beyond these again come the metamorphic rocks. Bays, as it were, of the carboniferous rocks run up the valleys of Anderson's Rivulet and the Middle Arm Creek, the boundary of the two formations (silurian and carboniferous) following a contour line at one general level. The serpentine occupies an oval or lenticular-shaped mass about three miles long by one mile wide, in the valley of Anderson's Rivulet, having its northern extremity near the junction of the silurian and carboniferous formations, and the whole of its length entirely in the former.

I will now proceed to describe the different formations in their order of superposition, from the oldest upwards.

The metamorphic rocks, the lowest and oldest in geological position, form the highest ranges in the district, and the watershed between the River Tamar and the Port Sorell River, and lie at from four to seven miles west of the former river. Their general direction is from N. 20°—30° W., which determines the strike of the other formations and the course of the river. They are chiefly composed of mica schist, quartzite, grit, and clayslate; but, owing to their densely scrubby character, and the prevalence of heavy bush fires, I did not examine them, and will pass to the next formation in ascending order, the lower silurian (of Gould).

This forms a series of nearly parallel ridges, composed of silicious sandstones, grits and conglomerates, micaceous sandstones, shales, slates, and limestones, &c.; the harder indurated silicious rocks forming the summits or backbones of the ridges, the shales and sandstones the flanks of the ranges, and the limestones the valleys. From their association with large limestone belts, I should be inclined rather to class them as upper silurian, in the absence of any fossil evidence of their age. The conglomerate is locally called by the Brandy Creek, or Beaconsfield, miners, "Cabbage-tree," from the range of that name there. The matrix of this conglomerate contains occasionally specks of *chromite* (which is

absent in the enclosed pebbles), and is coloured green by *chrome-ochre.* These ridges are between 300 and 400 feet above sea-level. There are three limestone belts of some importance. One is situated on the Middle Arm Creek, at the Launceston track crossing, and is a white *marble* of fair quality. Another, on the same creek and about half a mile south-west of the last, is a blue or dark grey limestone with *calc-spar* veins. *Gold* is said to have been found in the creek here, and *galena* in the limestone. The third is situated about three miles south-east of Douglass' (the Ilfracombe ironworks), and is similar to the last. There are also three iron lodes in this formation, as well as indications of more. The first is at the north-east end of the Ilfracombe or Blue-peaked Range, and consists of a fibrous and botryoidal *brown hematite* or *limonite* (kidney ore), which seems to be of great extent, but has not yet been opened up. An analysis of this ore in Mr. Newbery's laboratory gave—

Ferric oxide ...	79·34	= 55·54 per cent. of metallic iron.
Silica	15·30	
Combined water	5·16	
	99·80	

Eliminating the silica gives :—

Ferric oxide ...	93·71	= 65·59 iron.
Water	6·09	
	99·80	

Sulphur, phosphorus, and chromium were sought for, but not found.

The second lode is nearly in the centre of the same range, but on its west side at Douglass'. This has been worked by the Ilfracombe Co. to a small extent.

The ore is like the last, and gave on analysis—

Ferric oxide ...	91·14	= 63·94 per cent. metallic iron.
Silica	2·30	
Combined water	6·20	
	99·64	

Eliminating the silica gives :—

Ferric oxide ...	93·29	= 65·30 per cent. iron.
Water	6·35	
	99·64	

Manganese, chromium, sulphur, and phosphorus were specially looked for, but not found.

Pure hydrous oxide of iron should contain 59·89 per cent. of metallic iron, and 14·44 per cent. of combined water. From the water in these ores being present in only about one-third the quantity that it should be, it would seem that the ores are a mixture of the anhydrous oxide *(red hematite)* and the hydrous oxide *(limonite)*. The third lode is at the limestone quarries last mentioned, and has not been worked. There is a doubt about the age of the second lode (at Douglass'), and it is possible that, when properly explored, it may prove to be an ore-bed of carboniferous age. These lodes are all more or less at right angles to the prevailing strike of the rocks bounding them. Other smaller outcrops occur, but are not of much importance.

Mr. Gould's theory that the "iron deposits and outcrops are referable to one line of force, determining lines of fracture, which, in the sandstone and grit formations, have been filled with crystalline brown hematite, and, in the serpentine, with magnetic oxide," will not hold good, as he has evidently suited the position of these deposits and outcrops on his map to his theory. His supposed line of fracture is a north-west one, in the strike of the country, and the true lodes are nearly all east and west, or almost at right angles to the strike; whilst the ironstone deposits, mentioned further on, are undoubtedly tertiary cappings, which may or may not have connection with lodes below, of which, however, there is no evidence other than the occurrence of masses of *magnetic iron* in the *limonite*.

The only reefs known to be auriferous are those at Brandy Creek—but at the time of my visit the only reef yielding good returns was the celebrated "Tasmania." Other reefs struck payable-looking stone, but had to wait the advent of a long-promised crushing company.

In the area occupied by *serpentine*, the highest hills consist at their summits of a coarse or fine-grained glittering black rock—a gabbro, composed apparently of a triclinic *feldspar* and brown *mica*, or perhaps *diallage*. These points, of which there are six or seven, are scattered unconnectedly round Mount Vulcan. The gabbro passes rather abruptly, on the flanks of the hills, into a very uniform, both in texture and colour, deep green, oily-looking, semi-translucent rock, with bluish opaline veins, showing rarely traces of lamination, or seeming bedding planes, which have

the same direction as those of the adjoining silurian rocks; below which, and in the valley, the rock loses all traces of stratification, and occurs in a great variety of forms of very variable composition. It is full of veins of *chrysotile*, an analysis of which in Mr. Newbery's laboratory, by Mr. Frederick Dunn, gave—

Silica	43·55
Magnesia	38·04
Protoxide of iron	6·41
Lime	traces.
Alumina	traces.
Water (combined)	11·67
	99·67

Occasionally grains of *chromite* and *magnetite* are thickly distributed in layers. *Magnetite* also occurs in thin veins, and unconnected, striated, or longitudinally grooved slabs, with *asbestus* lying in the external grooves. The decomposed rock often contains veins and nodules of *wad* (hydrous oxide of manganese). Singularly enough this mineral is never seen in the undecomposed rock. From a shaft on the top of Mount Vulcan, the rock contains thin veins of a mamillated, apple-green, soft, waxy-looking, translucent mineral, which, by a blowpipe determination by Mr. Morley, proved to be *genthite*, or silicate of nickel, a somewhat analogous occurrence to the nickel ores of New Caledonia. All the rain channels off the serpentine hills contain minute, glittering, black octahedrons of *chromite* and *magnetite*. A small feldspathic or euritic granite dyke traverses the centre of the serpentine in the usual strike of the country. On the east side of the serpentine hills there is a variable amount of local attraction from north towards west.

The carboniferous rocks, consisting of nearly horizontal conglomerates, sandstones, limestones, &c., occupy generally all the low levels round the western arms of the Tamar. They rest against the flanks of the silurian ranges, pass under the greenstone, and reappear again on the eastern side of the river on the eastern flanks of the Tippagory Ranges, where the eastern edge of the basin rests against silurian rocks in the same way as its western edge does. This formation includes some valuable beds of limestone, exceedingly rich in fossils. A totally unconnected occurrence of these rocks is on the high divide separating the head

waters of Middle Arm Creek from those running south in the neighbourhood of the Ilfracombe lode.

The question as to whether or not *coal* is likely to be found in the district is an exceedingly puzzling one. Very little, if any, prospecting for it has been done; but just before leaving Tasmania I heard of a 15-inch seam having been found a few miles south of Exeter, higher up the River Tamar, on John Plummer's ground, north of Rosefairs, but I had no time to examine into the reliability of the statements made.

The country to the east of the river consists of greenstone, with underlying carboniferous rocks, but Mr. Gould's map gives no indication of any coal seams.

Coal occurs on the Mersey, Don, and Forth rivers to the west, and at Fingal and Mt. Nicholas to the east. The Fingal coal measures are overlaid by greenstone and underlaid by upper palœozoic marine beds, containing fossils identical with those in the district I am describing. The seams are from six to eight feet thick, but the coal is of indifferent quality. The Douglass River coal is of better quality, but the percentage of ash is high. In Mr. Gould's report on the Mersey River coalfield, dated 29th October, 1861, page 7, he states, in regard to the Denison colliery, that "A dark blue clay, slightly calcareous, and intermixed with sand and mica, is thrown *down*, by a large fault, against the coal seam. It is highly fossiliferous, containing *orthonota, spirifera, pachydomus, fenestella, encrinites*, &c., &c. From this and other lithological differences in the strata, it appears that the coal here *underlies* the fossiliferous beds; at Coal Creek, the Mersey Coal Company's shaft was sunk entirely through fossiliferous beds. The seams are greatly faulted."

The fossiliferous marine beds south of Yorktown would, by a calculation of their dip, supposing no faulting to occur, underlie the British and Tasmanian Charcoal Iron Company's works at Port Lemprière by over 5000 feet; but it is evident by an inspection of the dip of these beds at different localities that such a fault or faults must occur. The angle of dip varies very greatly, being larger at the edges of the basin where the rocks are tilted up than towards the centre at Middle Arm. At Middle Island the dip is reversed, so that the thickest part of the basin is probably in the neighbourhood of Port Lemprière.

Of the greenstone little need be said. It has been spread

out like a lava sheet, at what time it is impossible to say. It is not interbedded here, but is, I believe, in the Fingal district; and, if so, it is of carboniferous age. Its only covering in this district now is a tertiary drift, although an older one may have been denuded away. It occupies a very small area, but is largely represented to the east of the river.

An older pliocene tertiary drift, derived from the denudation of the silurian rocks and their contained reefs, covers the entire area of the higher portions of the low country between the two arms, almost completely obscuring the underlying rocks. It also caps the silurian and serpentine hills up to elevations of nearly 300 feet above sea level, between the Cabbage-tree Range and Anderson's Rivulet. It is very widely spread; but I have little doubt but that "leads" would be found, if looked for, in some portions of it. The Italian's and Scotchman's Company tunnelled into it on a head of Brandy Creek, west of the Cabbage-tree Range, and struck a "lead," with good prospects, but were driven out by water. "Made hills" occur along the valleys of the Yorktown and other creeks running up into the silurian and metamorphic ranges.

The ironstone hills, Mounts Vulcan and Scott, and Barnes' Hill, as well as other small outliers, would appear to belong to this period. Of the latter, the Tamar Company's ironstone, being off the serpentine, and free from *chromic iron*, yielded very fine pig iron, but is now worked out. Mounts Vulcan and Scott, the property of the British and Tasmanian Charcoal Iron Company, are situated about five miles southerly from their works at Port Lemprière, with which they are connected by a railway. Mount Vulcan is 278 feet above sea level, and consists of more or less decomposed serpentine. The iron ore (*limonite*) is evidently of tertiary origin, filling a pocket or depression on the north sides of the hills similarly to many European deposits. The top of the hills is covered with an agglomerate of ironstone pebbles, which are polar-magnetic, and the flanks with flat, striated pieces, from a quarter to half an inch or more thick, of *magnetite*, derived from veins already mentioned. The striations or grooves of the *magnetite* correspond with and run in the same direction as the *asbestus* fibres enclosing it. In some larger blocks of *magnetite*, occurring in the *limonite*, the grooves, instead of being straight, are much twisted, and resemble the foliations of metamorphic schists. Some of the

magnetite is polar-magnetic, some simply magnetic. The flat pieces are all magnetic; but one specimen was polar-magnetic at right angles to the striations. The massive *limonite* occurs in large irregularly rounded blocks, imbedded in a ferruginous gravel. It becomes more compact in depth, and has an average thickness of about twenty feet. Borings on Mount Vulcan were stated to have passed through strong lodes of *magnetic* iron; but some shafts put down by Mr. Scott, the Company's manager, and myself, proved their utter unreliability, as no *magnetite* was met with at considerably below the depths stated. The chromium occurs in the *limonite* in the form of *chromite* or chromate of iron, as glittering black specks, and seems to be in the largest quantity in the densest ore. The *magnetite* does not appear to contain chrome. At Barnes' Hill there is a very large extent of ore of a similar character to that already described. A peculiarity of it is that all the surface specimens of *limonite* were more or less magnetic, though I failed to detect any *magnetite*, as at Mounts Vulcan and Scott.

Mr. Gould supposes these ironstone deposits to be the "backs" of strong lodes of magnetic iron ore, and that the drift of *magnetite* on the flanks of the hills points to the existence of veins of magnetic oxide of some size. This may or may not be the case; but the ironstone is, I think, a secondary product, formed by deposition from ferruginous waters issuing as springs round the shores of the then arm of the sea, when the land was at a much lower level, and the gabbro was undergoing metamorphism into serpentine by the process of double decomposition described by Dr. Sterry Hunt. The chromium has been picked up, together with the sand the ore contains, during the contemporaneous formation of the ore and the denudation of the neighbouring hills. The ores vary from ferruginous grits to solid *limonite;* cavities between the denser ore bands are filled with ochreous clay and quartz grains, and the ore is concretionary. The boulders of solid ore have probably once belonged to a solid mass, which, in cracks and joints, has undergone partial oxidation and decomposition *in situ*, the looser gravel and ferruginous ochery clays being the result. Wherever ironstone occurs off the serpentine it contains no chromium.

This ore produces a metal much resembling "spiegeleisen," or manganese iron, and makes good steel, but the percentage of chromium is too high for pig iron. In the present state of metallurgical science, chromium cannot be

separated on a large scale economically from the ore, and it forms in smelting two or more definite chemical compounds in the pig iron, which render it very hard and brittle. The chromium compounds obtained from the Company's pig iron formed the subject matter of a paper by Mr. J. Cosmo Newbery, B.Sc., and Mr. Frederick Dunn, read before this Society on 12th December, 1878.

On the east side of the Brandy Creek, or Cabbage-tree Range, there occur some small leads, consisting of a reef-wash from the "Tasmania" reef, which probably belongs to the older middle pliocene period. Brown's party were on good gold at a depth of 60 feet; while, only about one and a half chains to the east, the Grand Junction Company were down 118 feet without bottom, showing the existence of a ledge between the two, with a very steep vertical fall.

Several companies were at work sinking for a supposed "deep lead" along the eastern foot of the Cabbage-tree Range, with very contradictory results. The height of the surface is about 75 feet above sea level. The Ophir Company had sunk 100 feet, and had passed through a fine white fireclay and a thick bed of *lignite*, containing a small quantity of *iron pyrites*, some quartz pebbles, and numerous fossil fruits, some of which have been recognised by Baron Von Müeller as *Spondylostrobus Smythii* (Müeller), which occurs in the "leads" at Nintingbool (Haddon), Beechworth, and Tangil in Victoria, and at Orange in N. S. Wales; *Conchotheca turgida*, occurring at Haddon and Tangil in Victoria, and at Orange and Darling Downs in N. S. Wales; and *Platycoila Sullivani*, occurring at Tangil in Victoria, and Orange in N. S. Wales. Some leaves were also found, but have not yet been described. Fossil fruits were also found in the Union Company's ground. Although all the claims are situated within 15 chains of the "Tasmania" tunnel, some have lignite, and are tolerably dry (Ophir); others with lignite are very wet (Union); some have no lignite (the Working Miners' Company, only 3 chains south-east of the Ophir) and much water; and others were nearly dry. None of the companies had then bottomed, and some were over 60 feet below sea-level. The flat country, from the foot of the ranges, has probably been an estuary in later tertiary times, and local deposits of lignite have been formed in sluggish tidal inlets, cut out at the junction of the silurian and carboniferous rocks, since which there must have been considerable subsidence. Some boring was being done to the north-east of

Brandy Creek, with, I should imagine, but very slight prospect of obtaining anything, except perhaps coal. They also had met with some lignite. These lignite beds probably belong to the newer middle pliocene period.

To the newer pliocene period may belong the creek "leads" on both sides of the Cabbage-tree Range, and also the extensive wash of pebble drift of various kinds, mixed with angular quartz and "cement," over the low country—a drift derived from the disintegration and denudation of the older tertiary hill cappings, and the underlying rocks where exposed. An old creek bed of this age probably connects two angles of Anderson's Rivulet in the village of Leonardsborough, and may be auriferous.

Concretionary ironstone crops out on the west side of the Middle Island, with a N. 10° E. strike, and an apparent easterly dip under the greenstone. A similar concretionary and rather sandy ironstone, with ochreous kernels, occurs in loose boulders all round the arms at high-water mark, and as a thin bed on the beach south of Ilfracombe village reserve. It seems to be the remains of a pre-existing deposit, resting upon the carboniferous rocks. Its age is doubtful.

Immediately in front of Dowlin's Hotel at Brandy Creek is a bed of *limonite* about 12 chains long by 5 chains wide, and of unknown thickness, from which issues a fine spring of water, flowing all the year round; the ironstone having probably the same origin as that at Mount Vulcan, although, perhaps, of later date.

In conclusion, I will briefly mention one or two other occurrences in connection with the reefs of Brandy Creek. Victorian reefs in general run in, or nearly so, the strike of the country; but here they make an angle of from 30° to 40° with the strike, or nearly east and west. The often-occurring carbonaceous or black schists forming the casings in many Victorian reefs are here represented by a brown, sometimes hard and silicious, and at other times earthy-looking, light and friable sandstone, containing distinct plant impressions, in the softer rock sometimes converted into *coal*. This occurrence has not been hitherto noticed, and is of great interest. This bed is said to form the hanging wall, in connection with the "Cabbage-tree" conglomerate, of the "Tasmania" reef, and I obtained specimens from their top shaft. The same rock also occurs in the shaft of the Providence Company on the top of the range. In

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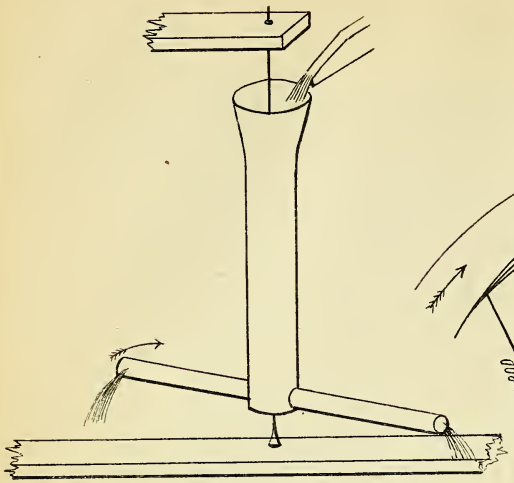

FIG. 1.

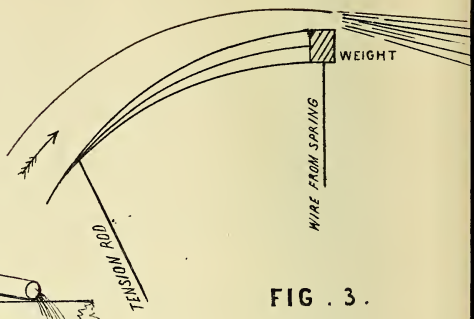

FIG. 3.

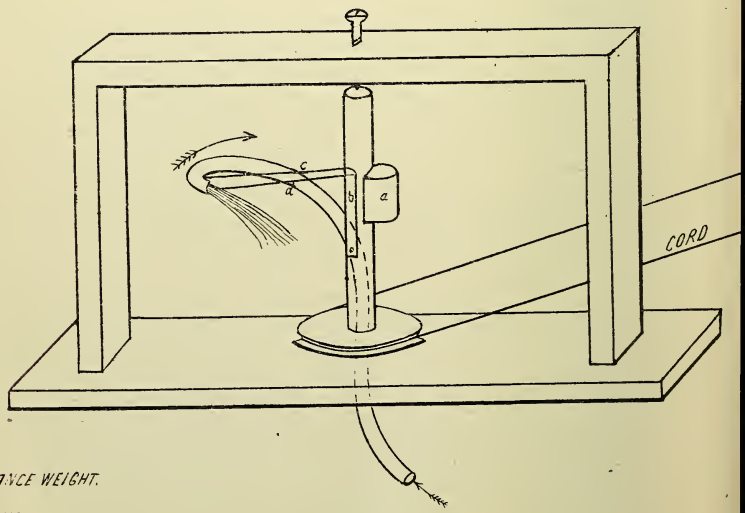

FIG. 2.

a. BALANCE WEIGHT.

b. SPRING.

c. TENSION ROD.

d. WIRE FROM SPRING TO JET.

the Grand Junction Company's shaft, on the eastern side of the range, it also occurs as boulders in the drift, and contains quartz pebbles, having no doubt been washed down from the reef in middle pliocene times. It contains gold in itself, and was being saved for crushing. Is it possible that these carbonaceous selvages to reefs have had any influence on or been the cause of the formation and segregation of gold in the reefs? Although much has been done by Mr. J. Cosmo Newbery towards a solution of this question, but with at present rather unsatisfactory results, still a great deal yet remains to be accomplished before an answer can be given to this important question.

Art. XI.—*Notes on Small Motors.*

By W. C. Kernot, M.A., C.E.

[Read October 9th, 1879.]

The general substitution of machinery for hand-labour in various industries during modern times has given to the question of prime movers an importance it did not possess in earlier periods, and has led to the perfecting of old and development of new expedients for obtaining mechanical power. Amongst these expedients the steam engine holds by far the most prominent place, while the various hydraulic motors, though of somewhat infrequent occurrence in the dry climate of Australia, are of inestimable value in localities where a constant fall of water is available.

But while the demand for motive power is very fairly met in the case of transport by land and sea, and of large establishments when numerous or comparatively heavy machines have to be kept in motion, it will, I think, be freely admitted that an important, and, as yet, but imperfectly occupied field remains for a cheap, simple, and easily managed motor of small power. We need a suitable contrivance for working small lathes, lapidaries' wheels, dental engines, sewing machines, grindstones, &c., for winding up large clocks, and for actuating various pieces of mechanism which are beginning to make their appearance in our private residences; in short, a cheap and convenient motor for the

small industries and for scientific and domestic purposes is undoubtedly one of the needs of the day.

This need has for some years past been recognised by mechanicians, and various machines have been devised, none of which, however, have been generally adopted. Amongst these may be mentioned diminutive steam engines, electro-motors, hot-air engines, and gas engines. The first of these are open to several serious objections. They are complex and delicate, need much attention, and, worst of all, are deficient in readiness, the process of getting up steam taking considerable time.

Electro-motors are simple in construction, and not easily deranged. The battery is here the objectionable feature, being a continued source of expense and trouble, and requiring the use of materials the presence of which is, to say the least, by no means desirable in the kitchen or larder.

Hot-air engines compare favourably with the preceding in most respects. They, however, are bulky and rather expensive, and need a fire continually maintained beneath them. The attention this fire requires and the waste heat radiated from it are objectionable, especially in small workshops and during warm weather.

Gas engines of from one to ten horse-power are very much in favour at present, and bid fair to supplant many of the smaller steam engines, especially in positions when the question of insurance is paramount. They are exceedingly convenient, being always ready, and needing no attention beyond lubrication. In first cost they are, however, very expensive, and all that I have yet seen are far too large for the purposes at present under consideration.

There is one source of power usually present in important towns which has yet to be noticed. In our street-mains we have a large supply of water under a considerable pressure, and capable of doing work to a corresponding extent; and if a suitable hydraulic motor can be found it is evident that we have here a source of power which for readiness and convenience can hardly be surpassed. This power has already been generally adopted for the purpose of working the bellows of large organs, but beyond this its application has hitherto been very limited.

To utilise the energy of the water is the question now before us, and for this purpose several kinds of motor are available. The ordinary piston and cylinder is very well suited when a comparatively slow motion is needed, as in

organ blowing, but is not so applicable when a rotary motion at a comparatively quick speed is desired. For such a purpose a turbine appears more promising; and it is next necessary to decide which of the various forms of turbine should be adopted. When used on a large scale, and with an ample supply of water, the merits of outward flow, parallel flow, inward flow, and reaction turbines appear very nearly balanced, the first cost not differing largely, and the efficiency lying between 60 and 80 per cent. in each case. But when the problem is to make the most of a very small stream of water at a pressure of not less than 50 lbs. per square inch, outward, parallel, and inward flow turbines need to be made of proportions, and to run at speeds which are practically objectionable. Wheels of not more than $1\frac{1}{2}$ inches in diameter, running at speeds of considerably over 5000 revolutions a minute, do not appear by any means desirable in a domestic motor, and hence we are led, as a last resource, to adopt the oldest form of all—the reaction wheel. With this we find it is possible to combine a comparatively large radius with a jet of the requisite dimensions, and thus obtain a machine the economical working speed of which is not impracticably high.

The reaction wheel has been known as a motor since exceedingly early times, and a rude form of it actuated by steam constituted the well-known *œolipyle*, or rudimentary steam engine of Hero, of Alexandria, B.C. 130. In a somewhat crude shape, adapted for water, it forms part of the apparatus of the physical lecturer, and is known as "Barker's Mill" (fig. 1). Of late years the questions of its economic speed and highest efficiency have been investigated mathematically and experimentally, and have led to its adoption on a large scale.

The following is a summary of our knowledge on the subject:—

1. With a perfect or frictionless fluid the efficiency of the reaction wheel increases toward unity as its angular velocity increases without limit.

2. In a well formed reaction wheel worked by water the best speed is approximately that at which the linear velocity of the jet is equal to $8\sqrt{h}$ where h is the head of pressure.

3. That at this speed an efficiency of fully 75 per cent. has been attained.

4. That in order to attain a good result, sharp bends and sudden changes in velocity of flow should be avoided, and

the passages so formed as to have as large a *hydraulic radius* as possible.

Fig. 2 represents a form of reaction wheel devised by the writer of this paper, and which is thought to fulfil the above conditions more perfectly than any hitherto adopted. There are no abrupt bends. The velocity of flow gradually increases in the tapered pipe, attaining its maximum at the terminal jet, and by adopting a circular section throughout, and having but one jet instead of two or more, as in previous forms, the *hydraulic radius* is kept as large as possible.

In the case of every hydraulic motor supplied with water through a pipe, there is a certain *critical velocity* of flow in the pipe at which the maximum development of power will take place. If the velocity be less than this, the power will be reduced and the efficiency of the system somewhat increased. In other words, the quantity of water expended will be reduced in a higher ratio than the power. If the critical velocity be exceeded, the expenditure of water will be enhanced, but both power and efficiency reduced. Adopting Darcy's views as to the friction of water on the walls of the pipe, this critical velocity can be shown by the aid of the differential calculus to be ·575 of the full velocity when the pipe is discharging freely, and at this speed one-third of the total head of the water will be employed in overcoming friction in the pipe, and the remaining two-thirds be available for the production of motive power.

The motor shown (Fig. 2) has been successfully applied to driving a small lathe for turning either wood or metal. At the outset, however, it was found that with such an irregular resistance as that of turning, inconvenient variations of speed took place, and water was wasted when the wheel was racing. This defect was partly remedied by the use of a fly-wheel, but was eventually more thoroughly obviated by means of a jet, the dimensions of which were altered by the centrifugal action of a weight, which, with its opposing spring, was so adjusted as to form an approximately isochronous system. The mechanical details of this contrivance are shown in Fig. 3.

The following tabulated statements show—1. The particulars and results of experiments to determine the power and efficiency of the motor; 2. The comparative cost of motive power per 1,000,000 ft. lbs., as derived from various sources; and 3. The approximate power required in order to perform several of the functions of a small motor.

PARTICULARS OF EXPERIMENTS.

Time, nine p.m.
Height above sea, 130 feet.
Hydrostatic pressure by gauge, 75 lbs.
Free discharge of pipe, 11·7 gals. per minute.
Radius of turbine, $4\frac{1}{4}$ inches.
Best speed, 1300 revolutions per minute.
Greatest power of turbine, 1800 ft. lbs. per minute.
Consumption of water, 2·8 gals. per minute.
Efficiency, 40 per cent.

This comparatively low efficiency is probably due to the small size and rude construction of the machine; on a somewhat larger scale and well made it may reasonably be expected to give at least 50 per cent.

When all the machinery was disconnected the expenditure of water was reduced by the automatic closing of the jet to ·75 gals. per minute.

A similar experiment was tried with the jet fixed open, when the turbine increased its speed to about 2000 revolutions a minute, and discharged considerably over 3 gals. per minute.

Comparative Cost of Motive Power, as Derived from Various Sources, *the Price of Coal, Labour, and Gas in Melbourne being taken as a basis of computation.*

	Pence.
1. Large marine engines of the most modern type, per million ft. lbs.	·20
2. Stationary condensing engines of less than 100 indicated horse-power	·35
3. Non-condensing stationary engines of less than 50 indicated horse-power	·45
4. Large gas engines of the most improved type	·90
5. The above-mentioned turbine, as tested (water at 1s. per 1000 gals.)	18·5
6. Manual labour at a crank-handle	55·0

POWER REQUIRED TO PERFORM SEVERAL OF THE FUNCTIONS OF A SMALL MOTOR, AND CORRESPONDING COST OF WATER FOR THE TURBINE, *under the same conditions as to Pressure, &c., as those obtaining during the experiments.*

	Foot Pounds of Work per Minute.	Cost of Water per Hour.
		Pence.
Supplying wind to a small organ of 6 stops, using full organ	372	·41
Driving an ordinary sewing-machine...	416	·46
Turning a 16-in. grindstone for grinding carpenters' tools	2000	2·22
Driving a foot-lathe, turning wood or metal, average work	1350	1·50
	Foot Pounds per Annum.	Cost per Annum.
Winding-up a large turret-clock, such as that at the Richmond Town Hall	8,000,000	12/4

ART. XII.—*On the Yarra Dialect and the Languages of Australia in connexion with those of the Mozambique and Portuguese Africa.*

BY HYDE CLARKE,

Vice-Pres. Anthropological Institute; Vice-Pres. Statistical Society; Vice-Pres. Society of Arts; Cor. Mem. American Oriental Society; Mem. German Oriental Society; Hon. Mem. American Anthropological Institute; Hon. Mem. Byzantine Society of Constantinople; Cor. Mem. Ethnographic Society of Paris; Cor. Mem. Congress of Pre-historic Archæology; F. R. Soc. of Antiquaries of the North, of Copenhagen; F. R. Historical Soc.; F. R. Colonial Institute; Fellow Philological Society.

[Read November 13th, 1879.]

IN Mr. R. Brough Smyth's great work, *The Aborigines of Australia* (Melbourne, 1878), there will be found in the second volume much matter on the languages of Australia. Among these will be found a very long vocabulary of the Yarra dialect, of the Yarra River, of Melbourne, composed by Mr. John Green, Inspector of Aborigines.

Unfortunately, many common words are left out, so that comparison can only be imperfect. However, I found on examination that it compares directly with a body of languages in Portuguese Africa, being Class XI. of Koelle's Polyglotta Africana, and comprising Muntu, Kiriman, Marawi, Metó, Malatau, and Nyambau, being the languages of Mozambique. The words outside of Class XI. are found in Class X., being Bantu or Kaffir languages of Portuguese, Western, and Central Africa, being Congo, &c. Some words are found in Class IV. which is related to Class X.

The following list will show this, the Class X. words being thus marked [ ]:—

		Yarra.		Africa.
Man	...	kolise (koli)	...	[akala, Mugentandu]
Woman	...	bazarrook bajor	...	[baketo, Nyombe] [badshento, Kabenda]
Daughter	...	munggup	...	moanaka
Father	...	marmun	...	(mama, mother)
Mother	...	baboop	...	(baba, father)
Brother	...	banggannoo	...	panginndenge
Sister	...	latingata	...	ndengetu
Eye	...	mee, merring	...	meso
Tooth	...	leeang	...	leeno
Navel	...	moondok	...	matoku
Knee	...	barreng	...	bondo
Bone	...	ma-lingo	...	likuwa
Skin	...	morrok	...	[mungoto, lubalo]
Beak	...	barrgin-boon	...	poono
Knife	...	kal-been	...	mu-kalo mbene
Axe	...	karrgeen	...	koangoa
Spear	...	goeeon	...	[ngaya, lubalo]
Stone	...	moojerr	...	moara
Coal	...	kanendurr	...	kala
Rope	...	woodel	...	[wondi, Mbamla]
Stick	...	kalk	...	[koko, Kabenda]
Leaf	...	jerrang	...	[jish, Bumbete]
Yam	...	barrm	...	[mbala, Kabenéa]
Cot	...	bede-dil	...	[budi, Mimboma]
Mosquito	...	gogook	...	[ngomgu, Mbamla]
Lizard	...	tourroop	...	tabarrada
Little	...	wy-krook	...	[watola] [kasanj] to-kieve, Bumbete
White	...	lam-borreen	...	[a-pfurau]
Black	...	woo-gar-ring	...	woo-ripa

	Yarra.	Africa.
Young	boop	[biop, Kanyika]
Warm	loom-badin	[a-domu, Melon]
Go	yani	[yami, lubalo]
Come	wandeat	uta
Cough	kooningoon	[ekona, Orangu]
Die	wykit	ukoa
War	ngatang	ngondo koto
Sun	ngumi	[ekombi, Bugela] [nkima ; moon, lubalo]
Moon	meene-an	[moanya ; sun, lubalo]
Sky	woorwarra	wa-moluku
Day	karremeen	[muini, Musentandu]
Night	boerren	[buila, Kabenda]
Rain	al	epula
Don	warrong	[ewuru, Sobo]
Fall	baderin	[buidi, Kabenda]
Sit	ngalimbe	kala
Dream	yiook-gen	gona
Give	woonga	wunya
Cut	bundi	[batura, Kasonj]
Catch	banga-gat	[quata, Kasonj]
Two	bollo-wun	beli, peli

To the Yarra model belong Kabi, Gunbower, Tyntyndyer, Glenorchy, Horsham, Upper Richardson, Balmoral, Hamilton, Wickliffe, Avoca, Daylesford, Goulburn, Witouro, Jajourong, Kreen-koren-werro, Burapper, Ta-oringurong, &c.

As a further test, beyond the one Mozambique language answering to the Yarra, if we take other Australian roots, we shall find their correspondents in the other languages of the Mozambique. Thus, five roots for "man" and three for "hair" admit of being so compared.

The Echuca, Morcovia, and Sandford particularly show this, and the results are obtained from Moreton Bay, in North Australia; New South Wales in the east, and from Western Australia.

The following table illustrates this :—

	Australia.		Kirimandi, Africa.	
Man	Echuca	moanit	moanna	Marawi
	Yelta	maalee	mulo	Kiriman
	Morcovia	nunna	nona	Nyamban
	Balmoral	beng	boana	Marawi
Head	Gunbower	moorun	muru	Kiriman

	Australia.		Kirimandi, Africa.	
Hair ...	Wickliffe ...	marah ...	murit ...	Kiriman
	Yarra ...	yarro ...	ikarare ...	Muntu
	Gippsland ...	leet ...	lefu ...	Mutsaya
	Echuca ...	boka ...	[mbeta ...	Kisama]
Ear ...	Echuca ...	marrmo ...	maro ...	Matabau
	Yarra ...	wooring ...	nyaru ...	Marawi
Tooth ...	Echuca ...	derra ...	dino ...	Nyamban
	Sandford ...	tungung ...		
	Yarra ...	leeang ...	leeno ...	Marawi
Mouth ...	Sandford ...	mullong ...	malagu ...	Meto
	Morcovia ...	moun ...	[munua ...	Kabendo]
	Hamilton ...	kone ...	[li-kano ...	Lubalo]
Sun ...	Bulloo ...	tuni ...	etana ...	Muntu, day
			[tangu ...	Kabenda]
	Yarra ...	ngume ...	[ekombi ...	Pangela]
Two ...	Moreton Bay	bullae ...	beli ...	Kiriman
	Yarra ...	bollo-ween ...	peli ...	Kiriman
	N. S. Wales..	pulla		
I ...	Victoria ...	ngie ...	ni ...	Muntu
		ngan ...	ne ...	Nyamban
	S. Australia..	ngu		

It is very seldom that we can so distinctly lay down languages which are really related but widely distributed. There is, therefore, no mistake that the language of the Melbourne tribes is of common origin with those of Mozambique.

A curious circumstance will be noticed that, though the words may differ internally, they commonly begin with the same consonants in both continents. This serves to mark them; for in the class of languages to which they belong, the Bantu or Kaffre, the initial syllable is of great import.

This brings us direct to papers of the greatest authority on the Bantu languages, the late Dr. W. H. Bleek, contributed by him, at the request of Professor Huxley, to the Anthropological Society and Institute, and to be found in Vol. I. of the *Journal* of the Anthropological Institute.

From the consideration of the grammatical points, Dr. Bleek was fully convinced that the Australian languages were related to the Bantu, and this he developes in a most remarkable paper on general philology.

Here, too, he examines what another great comparative philologist (Bishop Caldwell) had done in the comparative grammar of the Dravidian languages as to the wonderful identity of the Australian first personal pronoun with the

Dravidian and some other Indian languages. Caldwell was, however, unable to trace detailed resemblances. The observations of Dr. Caldwell are, however, as worthy of careful perusal as those of Dr. Bleek.

The latter was near seizing the whole truth as to the Australian languages, but missed, first, from devotion to a theory he had laid down of subdividing languages as a type for classification. Next, he failed from the besetting mania of philologists of regarding chiefly grammatical forms, and disregarding words.

Were it not for these circumstances, Dr. Bleek, with his intimate knowledge of the Bantu family, must have identified the facts here given. Strangely enough, in the same volume of the *Anthropological Journal* is a paper and comparative table of Australian languages by the Rev. George Taplin, which contain the words.

Dr. Bleek recognised the connection of mythology with language, and the fact that the mythology of Australia is related to that of other regions.

The practices and culture of Australia are well enough known to present many features in common with those of the rest of the world, and the relation of an Australian mummy was only a few weeks ago illustrated by Professor W. H. Flower at the Anthropological Institute.

In order to explain the ground on which the observations of Dr. Caldwell and Dr. Bleek rest, it may be useful to refer to those which were made by me on the 22nd November, 1870 (*Journal*, p. 84). It results from the course of inquiry then instituted by me, that the Australian belong to a group of languages (and in this term I conform with Dr. Bleek), to which also belong the Bantu and the Dravidian.

These languages, although developed in common and from the same sources, constitute a group. Thus the result is that roots may be differently selected in Australian, Bantu, and Dravidian, and will not fit in together in each case notwithstanding their common origin. The resemblance between the Yarra languages and the Mozambique languages is, as already stated, much closer than is commonly found.

It has been the opinion of some distinguished anthropologists that Australia is a centre of the human race, from which India and Africa were peopled. However this may be, the facts now brought forward are, so far as language is concerned, in proof of the direct contrary. Africa, so far as

this evidence is concerned, is the great centre of languages, of mythology, and of civilisation.

As in another paper contributed by me High Africa has been treated on as a centre of culture, it is not necessary to go into the whole subject here.

The Australian languages will be found to belong to one of the earliest epochs of development of language in this group, but I am of opinion that the testimonies brought forward in Mr. Brough Smyth's work as to Australia having been, at some former period, under the influence of a white race, are correct.

As such, I should class, which I cannot now account for, though I have an hypothesis not yet tested, the curious circumstance that the names of languages in Australia are negatives. Now, a whole section in my prehistoric and protohistoric comparative philology and mythology is devoted to the exemplification of this remarkable characteristic of a negative series. Now one language is called the Kabi, and Kaba figures largely in many languages of the old world as a negative.

Mr. R. Brough Smyth, in *The Aborigines of Victoria*, Vol. II., page 8 (Trubner, 1878), says:—

"A great many of the languages of Australia are named after the word 'no.' The late Mr. Bunce states that the Melbourne people used to designate their language the words 'Nuther galla,' nuther meaning 'no.'

"The late Mr. E. S. Parker corroborates Mr. Bunce's statement. He says:—The natives distinguish the different talle, or languages, by their negations. Thus there is the Burapper dialect, spoken by the Mallegoondeet; the Utar dialect, on the Murray and Lower Goulburn—these words, Burapper and Utar, being respectively the negations of each language; and so of others.

"This system of nomenclature appears to prevail in the eastern and southern parts of the continent.

"The Rev. W. Ridley, M.A., eminent amongst the philologists of Australia, says the following are the names of some languages spoken in the interior:—1, Kamilaroi; 2, Wolaroi; 3, Wiraiaroi; 4, Wailwria; 5, Kogai; 6, Pikumbul; 7, Paiamba; 8, Kingi. The first five of these are named after their negatives. In the first, Kamil signifies 'no;' in the second, Wol is 'no;' in the third, Wira is 'no;' in the fourth, Wail is 'no;' in the fifth, Ko is 'no.' In Pikembul, on the other hand, Piku means 'yes.'"

Indeed, the whole evidence is in confirmation of what has been stated by me (*Prehistoric Comparative Philology and Mythology.* London: Trubner), that under the doctrine of the four worlds, taught in the school of Pergamos, the ancients preserved a knowledge of what was known to their predecessors in Babylon. The Austral world, which in the globe balanced our world, was Australasia, as in the other hemisphere the north and south worlds were North and South America.

Thus the knowledge of this intercourse was long lost, until now we can restore a passage of many thousands of years old in the history of Australia.

Art. XIII.—*Observations of the Outer Satellite of Mars in* 1879.

By E. J. White, F.R.A.S.

[Read December 4th, 1879.]

As is now well known, the satellites of Mars were discovered by Professor Hall, of the Washington Observatory, by means of the magnificent refractor of 26 inches aperture, constructed for that establishment by the celebrated makers, Alvan Clark and Son, of Boston. Deimos, the outer satellite, was first seen on August 11th, 1877, and Phobos, the inner satellite, on the 17th of the same month.

Assisted by the positions furnished by the Washington astronomers, several observers in Europe and America managed to see these minute bodies, which in the most powerful telescopes appear as mere specks of light, with no measurable disc. Estimates, however, of their dimensions have been made from the intensity of their light, from which the diameter of the inner one has been fixed at from ten to forty miles, and the outer one between five and twenty miles. A little time after their discovery the Astronomer Royal, Sir George Airy, announced the fact to us in a telegram, and a search was at once instituted with the 4-foot reflector and 8-inch refractor of the Melbourne Observatory, but our efforts were not rewarded with success.

Although the opposition which occurred on November 12th of this year was not nearly so favourable as that of 1877—the nearest approach of Mars to the earth in the former case being 44,866,000 miles, and in the latter only 35,030,000 miles—yet as elements of the orbits had been computed by Professor Hall from the whole of the 1877 observations, which, notwithstanding that the outer satellite would have made more than 600 revolutions since it was last observed, he expected would not err more than 3° in giving the place of the satellite in its orbit, it was considered advisable to renew the search, for when once the place of an object is approximately known, it is much more easily seen than in sweeping for it.

It was considered quite useless to look for Phobos, which, although brighter than Deimos, would be always so near the body of the planet as to be completely overpowered by its great amount of light. It may be mentioned that although Mars would not approach the earth so closely as in 1877, yet it would be closer than during part of the time while Deimos had been visible, for it had been observed at Washington till Mars was 55,273,000 miles from the earth. On the night of its discovery the distance of Mars was 38,769,000 miles.

Our observations were commenced on October 21st. An ephemeris was computed from *Hall's Elements* for each night, and particular attention was paid to those times when the angle of position was about 53 or 233 degrees, when the satellite would be at its greatest elongation from its primary, the distance being then a maximum, which in the present opposition would amount to 67 seconds of arc from the centre, and about 49 seconds from the limb of the planet. To provide, however, against any great error that might possibly exist in the *Elements* Mr. Ellery instituted relays of observers, so as to extend the watch throughout the night. The eye-piece employed was a negative one, magnifying 255 times; to protect the eye from the glare of Mars a bar of blackened paper about four times the diameter of the planet was placed in the focus of the eye-lens. To this was afterwards added another bar at right angles to the former, thus forming a cross, which greatly facilitated the estimation of angles of position. During the search Mars was kept completely concealed behind one of these bars.

The nights of October 21st, 22nd, and 24th were fine, but nothing could be seen. The night of the 25th was unusually

fine; still no satellite could be detected. It was remarked, however, that a star of about the sixteenth magnitude which appeared in the field got almost completely obliterated when it approached within six diameters of Mars.

The moonlight now began to interfere with the search, and advantage was taken of the interval to try a series of experiments for improving the definition by cutting off some of the extreme rays from the mirrors. Increased sharpness was thus obtained, but at the expense of so much light that the full aperture was always employed afterwards.

On the morning of November 5th, between 2h. 15m. and 2h. 30m., Mr. Turner got a glimpse of a speck of light in the position indicated by the ephemeris; but clouds soon came up, so that it could not be seen long enough to know whether it was following Mars or not. On the evening of this day the observations extended from 9h. 0m. till 11h. 30m., but nothing was then seen.

On November 6th the night was fine, with occasional hazy intervals. The best position was computed to occur a little before midnight. At about half-past twelve Mr. Turner got a few momentary views of the satellite; he sometimes thought it bright enough to measure its position. Nothing like continued vision, however, could be obtained for even a few seconds, so that all attempts at measurement were unsuccessful. I also took part in the observations of this night, but at no time could I see the satellite.

On November 13th the night was cloudy and wet till 10h. 15m., when it cleared up; soon afterwards Mr. Turner saw the same object as on the 4th and 6th instants. Attempts to measure the place were made with the micrometer, but without success. According to estimation, however, the position angle was 54°, and distance $2\frac{1}{2}$ diameters from the following limb of Mars. The observer remarks:—"The speck seen had not a sharp appearance like a small star, but a nebulous look, and I at once recognised it as the same object seen on the previous occasions. It seemed to scarcely change its position with regard to the planet, though the motion was plain enough when referred to a twelfth magnitude star, which was at the same time in the field. I feel certain this is no optical illusion."

The night of November 15th was very clear, but the images were unsteady. At 8h. 55m. the satellite was seen at an estimated distance of $2\frac{1}{2}$ diameters from the preceding limb of Mars, and angle of position 235°. I also observed the

same object with comparative ease this evening, as likewise did Mr. Grieve, the assistant workman; but no measures could be taken, for the body always disappeared when it was brought near the bars.

On November 17th the best position was near the time of sunset. The night was fine, but Mars was too low, and for part of the time obscured by Government House. Just before 9h. 0m., when it became cloudy, Mr. Turner suspected a faint speck of light in the assigned position.

The night of November 20th was very cloudy till 10h. 0m., when it became very fine; the presence of the moon, however, interfered with the observations. A few fitful glimpses of the satellite were seen by Messrs. Ellery, Turner, Grieve, and myself, but the observation was so difficult that nothing like the same certainty was felt as on the former occasions.

At the time of our last observation Mars was 46,977,000 miles from the earth; at his next opposition in December, 1881, his nearest approach will be 56,063,000 miles. This will gradually increase till the opposition of 1886, after which a diminution will take place; so that, unless we have improved optical means, I think there is little chance of seeing those very minute bodies before 1890 or 1892.

The only other observations of Deimos at this opposition which have come under my notice are those of Mr. Common, in the south of England. He obtained his first observation on September 21st, or about three weeks before it was expected to be seen with the great Washington refractor, with which the original discovery was made. Mr. Common's instrument is a silver on glass reflector, of three feet in diameter. Mr. Common estimates the error of place in the orbit to be about 15°, corresponding to 1·3 hours. The estimates of position given by the Melbourne observers are necessarily very rough, for it was absolutely necessary to keep Mars completely behind the occulting bars to see the satellite at all.

1879.

PROCEEDINGS

ROYAL SOCIETY OF VICTORIA.

ANNUAL MEETING.

March 11th, 1880.

THE President in the chair, and sixteen members present.

The annual report and balance-sheet for 1879 were read and adopted as follow :—

"*Report of the Council of the Royal Society for the year 1879.*

"Your Council has the honour to report that during the past session one special and nine ordinary meetings were held. At the latter the following papers were read :—

"On the 8th May Mr. Ellery read a paper on 'The Relation Between Forest Lands and Climate in Victoria;' Sir Redmond Barry gave an account of some MSS. collected by the late Governor Latrobe, and at present deposited in the Melbourne Public Library; Mr. W. C. Kernot read a paper contributed by Mr. F. A. Campbell, C.E., on the 'Tensile Strength of some Australian Timbers.'

"On the 12th June Mr. A. W. Howitt, F.G.S., read a *précis* of his paper on the 'Diorites and Granites of Swift's Creek, Omeo; Mr. Ellery read some extracts from a paper by the Rev. J. E. Tenison-Woods, F.G.S., on 'A New Species of the Genus Amathia.'

"On the 11th July Mr. Bosisto read extracts from a paper by the Rev. Mr. Codrington, with Notes by the Rev. Mr. Fison, on 'The Customs of the Mota Tribes of the Banks Island;' Mr. J. Cosmo Newbery, B.Sc., read 'Notes on New Mineral Localities of Victoria.'

"On the 14th August Mr. Ellery read a paper on the 'Tidal Datum of Hobson's Bay;' Mr. Joseph read a paper on 'Professor

Hughes's New Induction Balance;' Mr. A. Sutherland, M.A., read 'Notes on the Method of Calculating the Increment in the Value of Land.'

"On the 18th September Mr. Newbery, B.Sc., exhibited specimens of serpentine containing gold, indicating a new mode of occurrence of that metal; Mr. Rawlinson, C.E., read a paper on 'Forestry and Forest Culture.'

"On the 9th October a paper was read by Mr. Taylor 'On the Geology of the West Tamar District of Tasmania;' and one by Mr. Kernot on "Small Motors.'

"On the 13th November the Hon. Secretary read a paper by Mr. Hyde Clarke on 'The Yarra Dialect and Languages of Australia, as compared with those of Mozambique and Portuguese Africa.'

"On the 11th December Mr. White read a paper on the 'Outer Satellite of Mars as seen at the Melbourne Observatory;' and Mr. Kernot described the machinery on board the s.s. 'Strathleven' for freezing meat. Mr. Ellery read 'Notes on Intermittent Siphons.'

"Volume XV. of the Society's Transactions was issued on the 10th April, and duly forwarded to members, and to the societies entitled to receive it. Volume XVI. is now in the press, and will be ready for issue in April next.

"During the year there have been elected seven new members and fifteen associates.

"The Council has effected an extensive alteration in the arrangement of the rooms of the Society's hall; the former lecture theatre being now converted into two rooms by an extension of the library floor across the full extent of the building. The interior of the whole house has been thoroughly renovated.

"Section A was formed at the beginning of the year, and has held its meetings monthly. They have been well attended."

The officers of the Society were elected as follow:—

President: Mr. R. L. J. Ellery, F.R.S.
Vice-Presidents: Mr. W. C. Kernot, M.A.
Mr. E. J. White, F.R.A.S.
Hon. Treasurer: Mr. P. de J. Grut.
Hon. Secretaries: Mr. E. Howitt.
Mr. Sutherland, M.A.
Hon. Librarian: Dr. J. E. Neild.
Council: Mr. R. E. Joseph, Mr. G. Foord, F.C.S.; Mr. J. Cosmo Newbery, B.Sc.; Mr. S. W. M'Gowan, Mr. F. J. Pirani, M.A.; Mr. R. Barton, F.C.S.; Mr. J. Duerdin, LL.B.

BALANCE-SHEET.

The Hon. Treasurer in Account with the Royal Society of Victoria.

Dr.

To Balance from last Balance-Sheet				£357	9	1
,, Government Grant, 1879-80				200	0	0
,, Interest on Fixed Deposit				12	13	9
,, Rents				69	3	0
,, Sale of Papers and Transactions				1	4	6
,, Five Entrance Fees				10	10	0
,, Subscriptions—						
53 Members	£111	6	0			
3 do. (Half-years) ...	3	3	0			
8 do. (Country)	8	8	0			
12 Associates	12	12	0			
9 do. (Half-years) ...	4	14	6			
Arrears	22	1	0			
				162	4	6
				£813	4	10

Cr.

By Printing and Stationery				£171	16	9
,, Payment, account of Alterations to Hall ...				150	0	0
,, Books				15	15	0
,, Freight and Charges of Books and Transactions				13	9	1
,, Conversazione				12	2	0
,, Insurance				2	17	6
,, Rates				4	13	4
,, Gas and Fuel				6	14	9
,, Furniture				1	15	6
,, Repairs				23	0	0
,, Clerical Assistant and Hall-keeper				26	15	0
,, Collector				18	14	11
,, Postages				18	9	3
,, Petty Cash				1	10	9
				£467	13	10
,, Balance in Bank—						
Fixed Deposit	£200	0	0			
Current Account	145	11	0			
				345	11	0
				£813	4	10

Compared with the Vouchers, Bank Pass-book, and Cash Book, and found correct.
2nd March, 1880.

H. MOORS
JAMES E. GILBERT } AUDITORS.

P. DE JERSEY GRUT, HON. TREASURER.

STATEMENT OF LIABILITIES AND ASSETS.

Dr. LIABILITIES.				Cr. ASSETS.			
To Publishing Fund	£216	11	2	By Balance in Bank	£345	11	0
,, Three Debentures outstanding	15	0	0	,, Estimated Value of Outstanding Subscriptions	25	0	0
,, Interest unclaimed	12	12	0	,, Rents due	47	0	0
,, Due to Contractor for Alterations	234	8	1	,, Hall, Library, Furniture, &c.	2650	0	0
	£478	11	3				
Balance	2588	19	9				
	£3067	11	0		£3067	11	0

PUBLISHING FUND.

Dr.				Cr.			
To Balance	£216	11	2	By Royal Society of Victoria	£216	11	2

Ordinary Meetings.

8*th May*, 1879.

R. L. J. Ellery, Esq., F.R.S., President, in the Chair—Present, 23 members.

Mr. J. E. Edwards and Mr. C. M. Maplestone were elected associates.

The Committee which had been appointed to consider the proposition to hold a series of winter lectures brought up their report, in which they recommend that a course of lectures be held during the winter months.

The report of the Committee was approved.

Mr. Ellery read a paper "On the Relation Between Forest Lands and Climate in Victoria."

A discussion followed, in which Sir Redmond Barry, K.C.B., and other members took part.

Sir Redmond Barry, K.C.M.G., read an account of a collection of MSS. relating to the early history of the Colony of Victoria, deposited in the Melbourne Public Library by the executors of the late Governor, Charles Joseph La Trobe, C.B. He moved that a Committee be appointed to confer with the Trustees of the Public Library to consider the advisability of printing the said MSS.

A Committee was then appointed for that purpose, who were also requested to to take into consideration the publication of the Burke and Wills records.

Mr. Kernot read a paper prepared by Mr. F. Campbell "On the Tensile Strength of some Australian Timbers," on which a discussion ensued.

(Signed) Robt. L. J. Ellery.

12*th June*, 1879.

R. L. J. Ellery, Esq., F.R.S., President, in the Chair—Present, 15 members and associates.

Mr. E. B. Heffernan, M.D., was elected a member of the Society.

Mr. W. H. Caught and Mr. W. E. Holmes were elected associates of the Society.

A circular from the Commissioners of the Melbourne International Exhibition of 1880, with reference to a Social Science Congress, was read and referred to the Council.

Mr. Alfred W. Howitt, F.G.S., read a *précis* of his paper "On the Diorites and Granites of Swift's Creek, Omeo."

The discussion of the paper was deferred until after its publication.

Mr. R. L. J. Ellery, F.R.S., read extracts from a paper "On a New Species of the Genus Amathia," by the Rev. J. T. Woods.

Arrangements were made for the formation of Section A as provided in the laws of the Society.

(Signed) ROBT. L. J. ELLERY.

11*th July*, 1879.

R. L. J. Ellery, Esq., F.R.S., President, in the Chair—Present, 16 members and associates.

Mr. Norman Taylor, Mr. C. M'Lean, and the Rev. J. J. Halley were elected associates.

Mr. Joseph Bosisto, M.L.A., read extracts from a paper by the Rev. Mr. Codrington, M.A., with notes by the Rev. Mr. Fison, entitled "Notes on the Customs of the Mota Banks Islanders." A vote of thanks was awarded to the author, and it was resolved that the paper be printed.

Mr. J. Cosmo Newbery read a paper, "Notes on New Mineral Localities of Victoria."

(Signed) ROBT. L. J. ELLERY.

14*th August*, 1879.

R. L. J. Ellery, Esq., F.R.S., President, in the Chair—Present, 21 members and associates.

Mr. J. R. Temperley, C.E., was elected a member.

Mr. F. A. Campbell, C.E., and Mr. J. J. Thomson were elected associates.

Mr. R. L. J. Ellery, F.R.S., read a "Note on the Tidal Datum of Hobson's Bay."

Mr. R. E. Joseph read his paper "On Hughes's Form of Induction-Balance."

Mr. A. Sutherland read his "Notes on the Method of Calculating the Increment in the Value of Land."

A discussion followed the reading of these papers; that on Mr. Sutherland's was adjourned to the next meeting.

(Signed) ROBT. L. J. ELLERY.

18*th September*, 1879.

R. L. J. Ellery, Esq., F.R.S., President, in the Chair—Present, 17 members and associates.

Mr. C. R. Blackett, M.L.A., and Mr. W. P. Beechervaise were elected members.

Mr. W. R. Guilfoyle and Mr. T. W. Fowler were elected associates.

The discussion on Mr. Sutherland's paper was concluded.

Mr. J. Cosmo Newbery exhibited specimens of serpentine containing gold, indicating a new mode of occurrence of that metal.

Mr. C. E. Rawlinson read a paper "On Forestry and Forest Culture."

(Signed) ROBT. L. J. ELLERY.

9th October, 1879.

R. L. J. Ellery, Esq., F.R.S., President, in the Chair—Present, 22 members and associates.

Mr. A. Semple was elected an associate of the Society.

A report from Section A was received.

Mr. Norman Taylor read a paper "On the Geology of the West Tamar District of Tasmania."

Mr. W. C. Kernot read a paper "On Small Motors."

(Signed) GEORGE FOORD.

13th November, 1879.

G. Foord, Esq., F.C.S., Vice-President, in the Chair—Present, 11 members and associates.

The Hon. Secretary read a paper by W. Hyde Clarke, V.P.A.S., "On the Yarra Dialect and the Languages of Australia in connection with those of the Mozambique and Portuguese Africa."

(Signed) ROBT. L. J. ELLERY.

11th December, 1879.

R. L. J. Ellery, Esq., F.R.S., President, in the Chair—Present, 24 members and associates.

Mr. J. R. Y. Goldstein and Mr. G. Manley Hopwood, F.C.S., were elected members.

Mr. E. J. White read a paper "On the Outer Satellite of Mars," as seen at the Melbourne Observatory.

Mr. W. C. Kernot described the machinery on board the "Strathleven" for freezing meat to be conveyed to England.

Mr. R. L. J. Ellery, F.R.S., read "Notes on Intermittent Siphons."

(Signed) ROBT. L. J. ELLERY.

PROCEEDINGS OF SECTION A.

Physical, Astronomical, and Mechanical Science, including Engineering.

At the ordinary meeting of the Royal Society, held June 10th, 1879, Mr. R. L. J. Ellery proposed that Section A should be again formed.

The names of about forty members were obtained who were desirous of becoming members of the Section, and now, after a lapse of more than four years, the Section is again doing active work.

Five meetings have been held, the average attendance being very good.

The first meeting was held on July 3rd, 1879, when the Chairman (Mr. W. C. Kernot) and Hon. Secretary (Mr. H. S. Patching) were elected. At this meeting Mr. Ellery exhibited a new contrivance invented by Mr. Grubb for obtaining uniform rotation with the use of the ordinary vibrating pendulum. Mr. A. Sutherland read a paper on "The Application of Mathematics to Political Economy."

At the meeting held July 30th Mr. R. E. Joseph exhibited a Hughes's induction balance. Mr. J. E. Edwards exhibited a new and improved form of telephone.

At the meeting held August 27th Mr. Kernot read some notes, and also exhibited some of Aitkin's experiments, on chains in rapid motion.

At the meeting held on September 24th Mr. Pirani exhibited the phenomenon of sound produced by electricity when a thin tense iron wire formed part of an interrupting electrical circuit. Messrs. M'Lean and Kernot each exhibited small models of turbines of original design, from each of which very good results were obtained; Mr. M'Lean's being a vortex wheel and Mr. Kernot's a Barker's mill.

At the meeting held on October 29th Mr. Pirani read a paper on "Methods of Teaching the Science of Electricity," suggesting some improvements in many of the definitions. The Secretary exhibited a new form of galvanometer.

It has been suggested that no recess shall exist with regard to the meetings of the Section, as observed with ordinary meetings of the Society; and as the laws do not provide for such recess, it is deemed expedient to hold meetings without interruption on the last Wednesday in every month, as decided at the first meeting of the Section.

W. C. KERNOT, *Chairman.*

H. S. PATCHING, *Hon. Secretary.*

MEMBERS

OF

The Royal Society of Victoria.

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Alcock, Peter C., Esq., Temperance Hall, Russell-street
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Fitzpatrick, Rev. J., D.D., Archbishop's Palace, East Melbourne
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Oliver, Calder E., Esq., Nagambie
Scourfield, R., Esq., Messrs. Scourfield & Coultas', Swanston-street
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Thompson, J. J., Esq., 11 Bouverie-street, Carlton
Willimott, Sydney, Esq., Waltham-terrace, Richmond

LIST OF THE INSTITUTIONS AND LEARNED SOCIETIES THAT RECEIVE COPIES OF THE "TRANSACTIONS OF THE ROYAL SOCIETY OF VICTORIA."

British.

Royal Society	London
Royal Society of Arts	London
Royal Geographical Society	London
Royal Asiatic Society	London
Royal Astronomical Society	London
Royal College of Physicians	London
Statistical Society	London
Institute of Civil Engineers	London
Institute of Naval Architects	London
The British Museum	London
The Geological Society	London
Museum of Economic Geology	London
Meteorological Society	London
Anthropological Society	London
Linnæan Society	London
Athenæum	London
College of Surgeons	London
Zoological Society	London
"Geological Magazine"	London
"Quarterly Journal of Science"	London
"Journal of Applied Science"	London
Colonial Office Library	London
Foreign Office Library	London
Agent-General of Victoria	London
"Nature"	London
University Library	Cambridge
Philosophical Society	Cambridge
The Bodleian Library	Oxford
Public Library	Liverpool
Owen's College Library	Manchester
Free Public Library	Manchester
Literary and Philosophical Society ...	Manchester
Yorkshire College of Science	Leeds

Royal Society	Edinburgh
University Library	Edinburgh
Royal Botanical Society	Edinburgh
Philosophical Society	Glasgow
University Library	Glasgow
Institute of Engineers of Scotland...	Glasgow
Royal Irish Academy	Dublin
Trinity College Library	Dublin
Royal Geological Society of Ireland	Dublin
Royal Dublin Society	Dublin

EUROPEAN.

Geographical Society	Paris
Acclimatisation Society	Paris
Royal Academy of Sciences	Brussels
Royal Geographical Society	Copenhagen
Academy of Science	Stockholm
Academy of Science	Upsal
Royal Society	Upsal
The University	Christiania
Imperial Academy	St. Petersburg
Imperial Society of Naturalists	Moscow
"Petermann's Geological Journal"... ...	Hamburgh
Society of Naturalists	Hamburgh
Royal Institution	Utrecht
Royal Netherlands Meteorological Society	Utrecht
Geological Society	Darmstadt
Linnæan Society	Darmstadt
Academy of Natural History	Giessen
Geographical Society	Frankfort-on-Main
Royal Academy of Science	Munich
Royal Academy	Vienna
Royal Geological Society...	Vienna
Royal Geographical Society	Vienna
Royal Botanical Society	Ratisbon
Imperial Academy	Breslau
Society for Culture of Science	Breslau
Royal Society of Sciences	Leipzig
Imperial Leopoldian Carolinian Academy of German Naturalists	Dresden
Royal Society	Berlin
Geographical Society	Berlin
Society of Naturalists	Halle
Physico-Graphico Society	Lund
Bureau of Nautical Meteorology	Stockholm
Academy of Arts and Sciences	Modena

Society of Natural Sciences	Cherbourg
Royal Academy	Amsterdam
Geographical Society	... Dresden
Royal Society	Gœttingen
Natural History Society	... Geneva
Royal Academy of Science	... Madrid
Royal Academy of Science	... Lisbon
Society for Culture of Science	... Bremen
Royal Academy of Agriculture	... Florence
Italian Geographical Society	... Florence
Academy of Sciences	... Bologna
Royal Institute for Science, Literature, and Art	... Milan
Royal Society of Science	... Naples
Academy of Sciences	... Turin
Scientific Academy of Leghorn	... Leghorn
Academy of Sciences	... Lyons
Physical and Medical Society	Würtemburg
Helvetic Society of Natural Sciences ...	... Zurich
Society of Natural History and Medicine ...	Heidelberg
Academy of Science	... Palermo
Society of Physical Sciences	Groningen
University of Leyden	... Leyden

American.

American Academy	... Boston
Geographical Society	...New York
Natural History Society	... Boston
Smithsonian Institute	Washington
American Philosophical Society	Philadelphia
Academy of Science	... St. Louis, Missouri
War Department, United States Navy ...	Washington
Department of the Interior	Washington
Davenport Academy of Natural Sciences ...	Iowa, U.S.

Asiatic.

Madras Literary Society	... Madras
Geological Survey Department	... Calcutta
Royal Bengal Asiatic Society	... Calcutta
Meteorological Society	Mauritius
Royal Society of Netherlands	... Batavia
Institution of Arts and Sciences	... Batavia

COLONIAL.

Parliamentary Library	Melbourne
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